African food tradition revisited by research

Project coordinator : Cirad
www.after-fp7.eu

The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 245-025

African Food Tradition rEvisited by Research

FP7 n°245025

Start date of project: **01/09/2010**

Duration: **51 months**

Deliverable number: **D 5.4.2.3**

Title of deliverable: Report on near-market consumer testing of new improved products in Europe for Group 3

Deliverable type (Report, Prototype, Demonstration, Other): Report

Dissemination level (PU, PP, RE, CO)*: PU

Contractual date of delivery: October 2014

Actual date of delivery: January 2015

Work-package contributing to the deliverable: WP5

Organisation name of lead contractor for this deliverable: ESB/NRI

Authors in Baobab and Bissap: M.J.P. Monteiro, A.I.E., Pintado, M. Cisse, A.I. Costa, G. Fliedel, A. Bechoff, I. Maraval, M. Boucher, D. Pallet, K.Tomlins , Pintado, M.M.

This document has been sent to:

The coordinator by WP Leader	Date: January 2015
To the Commission by the Coordinator	Date: January 2015

* PU: Public; PP: Restricted to other programme participants (including the Commission Services); RE: Restricted to a group specified by the consortium (including the Commission Services); CO: Confidential, only for members of the consortium (including the Commission Services)

Table of Contents

Executive summary

This deliverable describe the main results concerning the studies of European consumer acceptance of reengineered products from group 3 (plant based extracts for functional foods) in order to understand acceptance in EU markets and facilitate their promotion and introduction in these markets.

The products belonging to this group were Bissap - Hibiscus sabdariffa L., Baobab - Adansonia digitata L. and Jaabi - Ziziphus mauritiana Lam, but only Bissap and Baobab were submitted to European consumers testing. The methodological approach performed to establish consumer's acceptance and sensory profile included consumer hedonic acceptance, Just-About-Right intensity evaluation of specific descriptors (JAR) and Check-All-That-Apply questions (CATA).

Results on 4 reengineered Baobab fruit juices used in this consumer test showed that all fruit juices were evaluated as very sweet and slightly fruity flavour and very light colour and were in the acceptable range since the average scores were between 5 (neither like nor dislike) and 7 (like moderately), which can be considered satisfactory taking into account that the Baobab is not commonly consumed in Europe and even unknown to the public. For all the samples assessed the diluted from Syrup from Baobab fruit pulp (BSFP) showed to be the most appreciated and obtained a positive value on the consumption probability, possibly because this sample showed the highest values in the fruit odour and intensity and colour hue.

Results on 2 reengineered bissap drinks - an ultra-vacuum concentrate and a syrup evaluated in Europe by comparable consumers' samples in France, Portugal and United Kingdom, along with a hibiscus infusion prepared freshly from ground dried calyces, showed that all the hibiscus drinks evaluated were in average positively appreciated by consumers, however new drinks were significantly more appreciated then the traditional infusion. Similar preference profiles were observed across countries although French participants were those that most appreciated the drinks. Clusters analysis performed showed new hibiscus drinks were liked slightly too moderately by participants in Clusters C1 (*Overall likers*) and C2 (*New drinks' likers*), representing about 75% of participants in the study. The evaluation of the intensity of three sensory attributes - colour, sweet taste and acid taste -, relatively to participants' ideal level and it's relation with overall liking ratings, showed for reengineered syrup a significant negative impact of the high sweetness on the drink overall liking. Oppositely for ultra-vacuum

concentrate the strong colour and acidity and weak sweetness led to a significant decrease in overall liking. CATA profiles were similar in the three countries, concerning both the actual drinks tested and an ideal theoretical drink. Reengineered syrup was perceived to have a highly distinct sensory profile when compared with the others, and these with the described ideal drink.

In the case of reengineered syrup although being the most appreciated drink, its high sweetness was an important penalizing factor in consumers acceptance as a drink, nevertheless other uses for this syrup can be foreseen. In the case of ultra-vacuum concentrate drink where the strong character, robust colour and strong acidity was not so appreciated in Europe as in Senegal, could benefit European consumers' acceptance if we increase the dilution of the concentrate with an equilibrated degree of added sugar.

Besides exploring further opportunities for enhancing the sensory profiles of the new drinks of group 3 in line with European taste, future studies should also investigate the levels of marketing activities (pricing, distribution and promotional information – including nutritional and healthiness attributes) which will best support their successful introduction in European markets.

General approach

The work encompassed in this deliverable had as main objective the evaluation of European consumer acceptance of products from group 3 (plant based extracts for functional foods) that were submitted to reengineering process to overcome food safety and product quality issues (identified in the first stage of the project in traditional food) to facilitate their promotion and introduction to EU markets.

The products belonging to this group were Bissap - Hibiscus sabdariffa L., Baobab - Adansonia digitata L. and Jaabi - Ziziphus mauritiana Lam.

Bissap or Karkadé is obtained from the flower of Red Sorrel (Hibiscus sabdariffa L.). Dry calyx of the flower is used in Senegal and other Western African countries for the preparation of beverages and other products with high anthocyanins content.

Baobab or Bouye is a juice obtained from the fruit of the baobab (Adansonia digitata L.). The baobab is a tree that grows wild in all semi-arid and dry sub-humid areas throughout Africa and Madagascar. The fruit of the baobab or monkey bread, called Bouye in Senegal (Buy in wolof), is widely consumed in various forms.

Jaabi also called Jujube (Ziziphus mauritiana Lam.) is the fruit of the jujube tree, widely spread in the Soudano-Sahelian savannas of Africa, particularly in North-Cameroon. The fruit is locally used fresh or dried for food purpose. It is consumed as snack food or processed into flour for the preparation of pancakes, or also associated with pastry or drinks. The dried and processed fruit has a pleasant biscuit taste and a plain aromatic flavour.

The products selected for European studies of reengineered products at this stage were Bissap - Hibiscus sabdariffa L. and Baobab - Adansonia digitata L.. drinks. The consumer acceptance testing of the reengineering of product from Jaabi - Ziziphus mauritiana was performed in Cameroon and reported in Deliverable D5.5.2.3, but could not be tested in Europe since it is a very local product, with reduced processing expression, with reduced acceptability and with high seasonality, constraining commercial transference to Europe, and consequently from all the products from group 3 Jabbi was that with minor chances and interest in Europe, and for that no study was performed at this stage in Europe. In previous study in Europe sensory evaluation of the cake samples was carried out by 5 semi-trained panellists from CIRAD Montpellier (paper under submission), and sensory aspect of jaabi was not well accepted by the European consumer. For that reason, and because the reengineered product was only improved in terms of nutritional value with no sensory improvement, we did not reached conditions to test this product in Europe.

In this deliverable are reported results concerning consumer preference studies that instead of a trained panel used a large number (60 or more) of consumers, who scored the product only for liking or acceptance. This method assesses personal responses (acceptance or preference) of consumers regarding to a product, idea or specific product characteristics. In this deliverable are reported the reengineered product.

In order to efficiently assess the European consumer preference and perception of the products from group 3, the study was structured according the product, as follows:

Baobab study: Consumer preference study was performed with Portuguese consumers for reengineered Baobab products

Bissap study: Consumer preference study was performed as a cross study in Europe including Portuguese**,** English and French consumers.

These results helped to understand the perception of European consumers about these re-engineering products in order to promote its consumption in both European and African markets.

The studies will be presented by product in the following sections in order to easily show the particularities of each one.

1. Consumer preference study of Baobab reengineering products in Europe

1.1. Summary

The Baobab tree has an Arabic history, and belongs to the Bombacaceae family and Adansonia gender and the most common name of baobab fruit pulp in Senegal is “Monkey bread” or "Bouy".

Baobab samples for consumer test included Baobab traditional products submitted to reengineering processing under the AFTER project scope and resulted in four different samples: two syrups that were obtained from Baobab powder by two different processes: hot dissolution and cold dissolution and other two syrups produced from Baobab fruit (Esteval) and syrup from Baobab fruit pulp. All samples were diluted with potable water prior to tasting in order to standardize the Brix in the range of the sample used for comparison in sensory tests (commercial pear nectar) that corresponded to 11.1 ºB also used in sensory evaluation.

The study included a group of 73 Portuguese consumers with ages ranging 17 and 50 years old. Sample acceptability was assessed by overall liking ratings provided on a 9-point hedonic scale. Hierarchical cluster analysis (Ward’s method) was used to segment consumers accordingly. Sensory attributes– *colour, sweet taste acid taste and fruity flavour*, relatively to participants’ ideal level were measured by attribute ratings provided on a 3-point JAR scale.

The main results showed that for Baobab fruit juices used in this consumer test, all fruit juices were in the acceptable range since the average scores were between 5 (neither like nor dislike) and 7 (like moderately), which can be considered satisfactory taking into account that the Baobab is not commonly consumed in Portugal and even unknown

to the public. Syrup from Baobab fruit pulp (BSFP) was the most appreciated and obtained a positive value on the consumption probability.

1.2. Introduction

The Baobab tree has an Arabic history, and belongs to the Bombacaceae family and Adansonia gender.

There are eight species in the world including *Adansonia digitata L.*which is found in Senegal. This species is encountered in many African zones and has a long life. In many parts of Africa tubers, fruits, seeds, leaves and flowers of this plant are identified as common ingredients in traditional dishes in rural and urban areas. African baobab is a very long-living tree. It normally lives for about 500 years, but it is believed that some trees are up to 5000 years old (Gruenwald and Galizia, 2005)

The most common name of baobab fruit pulp in Senegal is “Monkey bread” or "Bouy". The baobab pulp is economically the most important food stuff, and is recognized by the EU commission as an additive and exported in many countries.

The fruit pulp is commonly sucked, chewed or made into a drink when mixed with water or milk, either with or without sugar, or as a supplement to mix with staple food such as corn meal and cassava. Other uses for baobab pulp include sauces for food, hair rinse, milk curdling agent and a substitute for cream of tartar, among other things.

The pulp is very nutritious. Arnold et al. (1985) reported that with na average of 8.7% moisture, the pulp contains about 74% carbohydrates, 3% proteins, 9% fibers, 6% ash and only 0.2% fat. The content of pectin is approximately 56% (Nour et al., 1980), which is why the pulp is traditionally used as a base for jam making. It is also characterized by a high vitamin C (ascorbic acid), calcium, phosphorus and potassium content. The acidulous taste is attributed to the presence of organic acids, such as citric acid, tartaric acid, malic acid and succinic acids.

Baobab fruit pulp has a particularly high antioxidant capability mainly because of its high natural vitamin C content, which is equivalent to 6 oranges per 100 g. If we consider that baobab has an ascorbic acid content of 300 mg per 100 g pulp, the oral intake of 25 and 30 g, respectively is able to provide the daily vitamin C allowance required by humans. Additionally, vitamin C aids the bodily uptake of iron and calcium,

of which the fruit pulp contains more than double than the same amount of milk. Therefore, in some areas, it is used as a milk substitute for babies.

Baobab fruit pulp, due to the combination of health claims (such as prebiotic and antioxidant functions, the high calcium content, and the anti-inflammatory properties) and food technological functions (because of its high pectin and fiber content, baobab fruit pulp gives beverages a thicker consistency and can be also used as filler), is a very interesting candidate for a new generation of functional foods and drinks. Baobab fruit pulp can be particularly interesting as an ingredient for smoothies, which are a kind of thick fruit juice with a high content of fruit pulp. From July 2008, "An exotic fruit with six times the vitamin C of an orange can be sold in Britain after an EU ruling.

In studies carried out under the project reengineering technologies were applied for optimization of a dried powder from Baobab pulp, which can be reconstituted when necessary for the production of Baobab drinks. Drying contributes to the shelf-life stability for the export market. From the dried powder Baobab syrups were produced using a new technology for improving these products.

The main objective of this research effort was to study the acceptability by Portuguese consumers of four Baobab samples (n=4), two syrups obtained from Baobab powder by two different processes: hot dissolution and cold dissolution. The other two samples were syrup produced from Baobab fruit (Esteval) and syrup from Baobab fruit pulp.

Consumer hedonic acceptance, Just-About-Right intensity evaluation of specific descriptors (JAR) were used to establish consumers acceptance.

1.3 Material and methods

1.3.1. Baobab samples and sample preparation

Baobab samples for consumer test were new Baobab syrups developed under the AFTER project scope and prepared according different protocols of Senegalese recipes.

The Baobab samples were four different samples: two syrups were obtained from Baobab powder by two different processes: hot dissolution and cold dissolution. The other two samples were syrup produced from Baobab fruit (Esteval) and syrup from Baobab fruit pulp.

All samples were diluted with potable water prior to tasting in order to standardize the Brix in the range of the control sample already used for comparison in sensory tests (commercial pear nectar) corresponding to ca. 11.1 ºB.

Four different samples were presented to consumers as the following (Figure 1):

1. Syrup from Baobab power cold dissolution (BSCD)
2. Syrup from Baobab power hot dissolution(BSHD)
3. Syrup from Baobab fruit pulp (BSFP)
4. Syrup from Baobab fruit (Esteval) (BSFE)

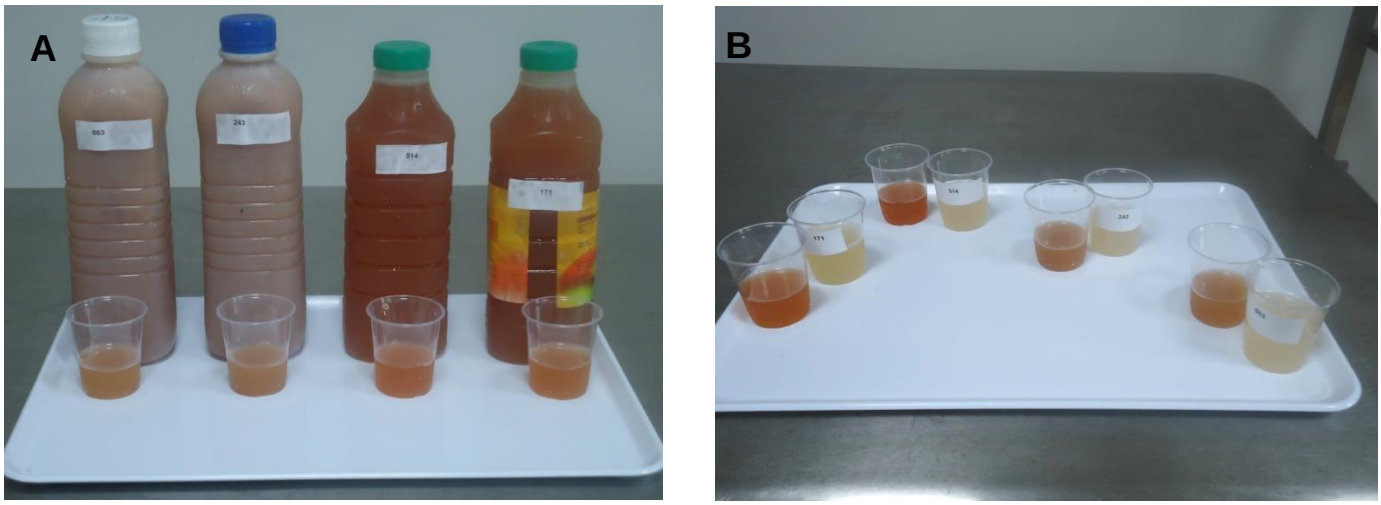


Figure 1 – A - Baobab syrups samples; **B -** Baobab syrups samples diluted for presentation to consumers.

Common to all of the methodologies is the Ethical assessment and consent which is listed as
follows:

1.3.2. Ethical assessment and consent

The study was reviewed by project AFTER's Ethics Committee. Participants were informed about the study's general aim and procedures for handling personal data, and gave written informed consent prior to participating in the tasting sessions. Interviewers informed participants about the study and explained that their participation was entirely

voluntary, that they could stop the interview at any point/time and that the responses would be anonymous.

All tested samples were produced and prepared according to good hygiene and manufacturing practices. The new drinks tested resulted mainly from incremental changes in the traditional manufacturing processes, with the aim of better extracting and preserving its nutritional value while increasing its eco-efficiency. No safety or health concerns were introduced by such changes.

1.3.3. Participants

Participants were non-probabilistically recruited in Portugal (Porto, n=75), according to their willingness and availability to participate in the study, however atypical overall liking ratings were observed for two participants and consequently they were excluded from further analysis (n=73).

All participants consumed fruit beverages and (62%) consumed fruit juice one or more times per week, (19%) consumed these types of juices daily and (19%) one or more times per month, 99% were European or European residents, and their ages ranged between 17 and 50 years old (average 28,8, standard deviation 10.2) and 74% were women.

1.3.4. Tasting sessions

Tasting session was conducted in the building of Escola superior de Biotecnologia (ESB) – Universidade Católica Portuguesa (UCP) in a room equipped with computers, since the questionnaire were conducted in portable computers. The questionnaire was written in Portuguese and was introduced in Qualtrics (Qualtrics, LLC) online survey software in order to simplify the collection of the information. Qualtrics is a software platform used by ESB – UCP.

Thirty millilitre samples of each of the Baobab drinks tested were served in clear plastic glasses, following a complete balanced experimental plan. The four Baobab samples for consumer tasting were the same as those used for sensory evaluation: Syrup from Baobab power cold dissolution (BSCD); Syrup from Baobab power hot dissolution (BSHD); Syrup from Baobab fruit pulp (BSFP) and Syrup from Baobab fruit (Esteval)

(BSFE). Each sample was identified by a random code with 3 digits. Water was supplied to clean the palate between tastings. Participants were informed the samples were non-alcoholic beverages and no other information was provided except for safety considerations. The samples were presented to consumers at room temperature therefore were taken from the refrigerator in advance (see Figure 2).

Figure 2 - Baobab syrups samples presentation and tasting sessions in ESB-UCP.

The questionnaires can be seen in Annex 1.

1.3.5. Consumer acceptance measures

Consumer acceptance was measured by overall liking ratings, provided on a 9-point hedonic scale (1 = "dislike extremely, 9 = "like extremely") (Jones, Peryam, & Thurstone, 1955; Peryam & Girardot, 1952; Peryam & Pilgrim, 1957). Hierarchical cluster analysis (Ward's method) was used to segment consumers accordingly. The intensity of four sensory attributes – *colour, sweet taste acid taste and fruity flavour* -, relatively to participants' ideal level, was measured by ratings provided on a 3-point, just-about-right scale [*too weak* (TW), *just-about-right* (JAR), *too strong* (TS)].

1.3.6. Statistical analysis

XLSTAT software (Addinsoft SARL, France) and IBM SPPS Statistics, Version 22.0 (IBM Corp., USA) were used to carry out all statistical analyses. The significance of statistical tests was evaluated at $p<0.05$, unless otherwise mentioned.

1.3.6.1. Consumer acceptance measures

Analysis of Variance (ANOVA) was performed on overall liking ratings for the three samples, considering participants and samples as sources of variation. Mean sample ratings were calculated and significant differences between them tested post-hoc using Tukey's HSD (Honest Significant Difference) tests. Pair-wise Pearson correlations between samples' overall liking ratings were then computed to assess their degree of association.

Hierarchical cluster analysis (Euclidean distances and complete linkage agglomeration method) was subsequently performed to identify groups of participants with dissimilar patterns of sample liking. Analysis of Variance (ANOVA) was performed on within-clusters' overall liking ratings for the four samples, considering participants and samples as sources of variation. Within-cluster mean sample ratings were calculated and significant differences between them tested post-hoc using Tukey's HSD tests. The existence of significant differences between clusters' mean ages was assessed using Student's t-tests. Finally, the existence of significant differences between clusters' gender proportions was evaluated by Pearson's chi-square tests with Monte Carlo procedure.

The frequency of intensity ratings (TW, JAR, TS) for each of the three sensory attributes evaluated by participants was determined for each sample, and the corresponding proportions calculated. A Correspondence Analysis (CA) was then performed on the contingency table of proportions for all samples and attributes (Popper, 2014). The frequency of intensity ratings for each sample and attribute was finally tallied for each cluster of participants based on overall liking ratings.

A penalty analysis (Popper, 2014) was employed to relate attribute intensity ratings to overall liking ratings for each participant and sample. To this end, participants were grouped according to their intensity ratings for each sample and attribute, and mean overall liking ratings for each group were computed. The overall liking mean drops, or

penalties, obtained when comparing the TW and the TS group with JAR participants were then calculated. Weighted penalties (Popper, 2014) were equally computed by taking both the mean drops and the proportion of participants in each group.

1.4. Results

1.4.1. Consumer study

1.4.1.1. Consumer Overall liking scores

The overall acceptability for the four Baobab samples showed that there were significant differences between the syrup from Baobab fruit pulp (BSFP) sample and the other three samples: syrup from Baobab power cold dissolution (BSCD), syrup from Baobab power hot dissolution (BSHD) and syrup from Baobab fruit (Esteval) (BSFE) at a significant level of $p \leq 0,01$ (one-way ANOVA) (Table 1), however there were not significant differences ($P>0,05$) for the samples BSCD,BSHD and BSFP.

Regarding all samples used during consumer study it was possible to verify that samples were on the positive range since the mean scores were between 5 (neither like or dislike) and 7 (like moderately).

Syrup from Baobab fruit pulp (BSFP) was the most preferred followed by syrup from Baobab power cold dissolution (BSCD), and syrup from Baobab power hot dissolution (BSHD) and the syrup from Baobab fruit (Esteval) (BSFE) obtained the lowest score, in a decrease order of magnitude.

Table 1 - Mean overall acceptability scores for Baobab samples tested.

Samples	Averages	Groups	
BSFP	**6,644**	**A**	
BSCD	**6,055**		**B**
BSHD	**5,918**		**B**
BSFE	**5,726**		**B**

5 Neither like or dislike
6 Like slightly
7 Like moderately

* Means with the same letter are not significantly different Tukey test ($p<0.01$).

1.4.1.2 Consumer Probability Consumption scores

The probability of consumption was also assessed in a consumer test. To the question "*Would consume this drink, if it is available in the market*?" consumer responses obtained for the four Baobab samples showed that were significant differences ($p \leq 0,01$) between the pulp of fruit syrup Baobab (BSFP) sample and the other three samples: syrup Baobab power of cold dissolution (BCSD), Baobab power syrup hot dissolution (BSHD) and fruit syrup Baobab (Esteval) (BSFE) (Table 2), but there were no significant differences ($P > 0.05$) for the BCSD samples, BSHD and BSFP. These results were similar to those obtained for the *Consumer Overall liking,* once as expected the *Probability consumption* and the *Overall liking* are directly related.

The scores obtained for Baobab samples were in the range from the mean values between 4 (medium probability) and 6 (a good probability). In similarity of the results obtained for *Overall liking*, the syrup Baobab fruit pulp (BSFP) obtained higher probability consumption scores, between reasonably and good probability of consumption, followed syrup Baobab power of cold dissolution (BCSD) and syrup Baobab power of hot dissolution (BSHD) and fruit syrup Baobab (Esteval) (BSFE) got the lowest score in a magnitude of reduction of order.

Table 2 - Mean overall probability consumption scores for Baobab samples tested.

Samples	Averages	Groups		
BSFP	**5,315**	**A**		**4 Medium probability**
BSCD	**4,247**		**B**	**5 Reasonably probability**
BSHD	**4,233**		**B**	**6 Good probability**
BSFE	**4,205**		**B**	

1.4.1.3. Consumers segmentation using Hierarchical cluster analysis

1.4.1.3.1. Consumer Overall liking

The hierarchical cluster analysis (Ward method) identified two groups of consumers that scored the overall liking scores of the samples differently, as depicted in Figures 3 and 4. Segmentation gives a more complex variation in acceptability among the consumers and is helpful to understand differences in consumer behaviour. The clusters

identified were: Cluster 1 (**C1)** - *Overall likers* (53%), Cluster 2 (**C2)** - *Syrup from Baobab fruit pulp likers* (47%). 53% of consumers (Cluster C1) considered like all the samples, whereas syrup from Baobab fruit pulp (BSFP) was liked by 100% of participants (clusters C1 and C2), however the syrup from Baobab fruit (Esteval) (BSFE) was the sample dislikers by 47% of participants (Cluster C2). Mean overall liking ratings showed that syrup from Baobab fruit pulp was better appreciated than the other samples assessed.

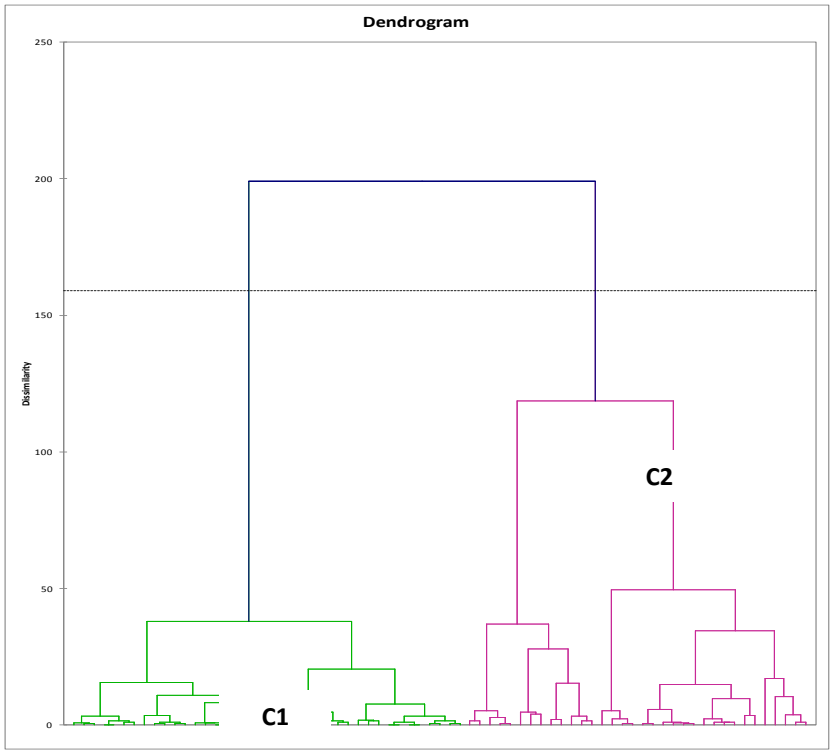
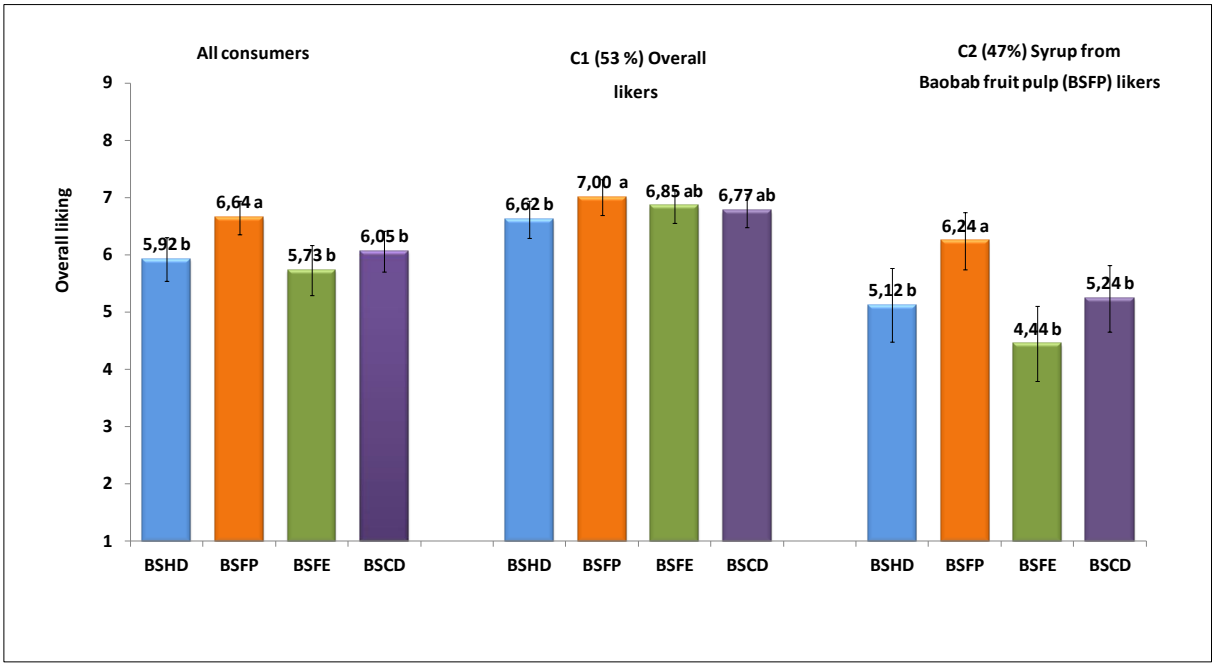


Figure 3 – Hierarchical clustering dendogram segmenting participants according to their overall liking patterns of Baobab samples (n=73; C1= 39 and C2=34).



*Error bars represent the confidence interval of the mean (p=0,95). Different superscripts within acluster indicate significant differences according Tukey's HSD ($p \leq 0,05$).

Figure 4 – Mean consumer Overall liking of Baobab samples: syrup from Baobab power cold dissolution (BSCD); syrup from Baobab power hot dissolution (BSHD); syrup from Baobab fruit pulp (BSFP); syrup from Baobab fruit (Esteval) (BSFE).

1.4.1.3.2. Consumer Probability Consumption

The hierarchical cluster analysis (Ward method) identified two groups of consumers that scored the Probability Consumption scores of the Baobab samples differently, as depicted in Figures 5. The clusters identified were: Cluster 1 (C1) - *Overall probability consumption* (53%), Cluster 2 (C2) - *Syrup from Baobab fruit pulp (BSFP) probability consumption* (47%). The results were similar to those shown above for Overall linking with 53% of consumers (Cluster C1) considered probably consumption the Baobab drinks assessed, whereas syrup from Baobab fruit pulp (BSFP) was the sample that obtained the highest probability consumption (clusters C2) when compared with others Baobab samples

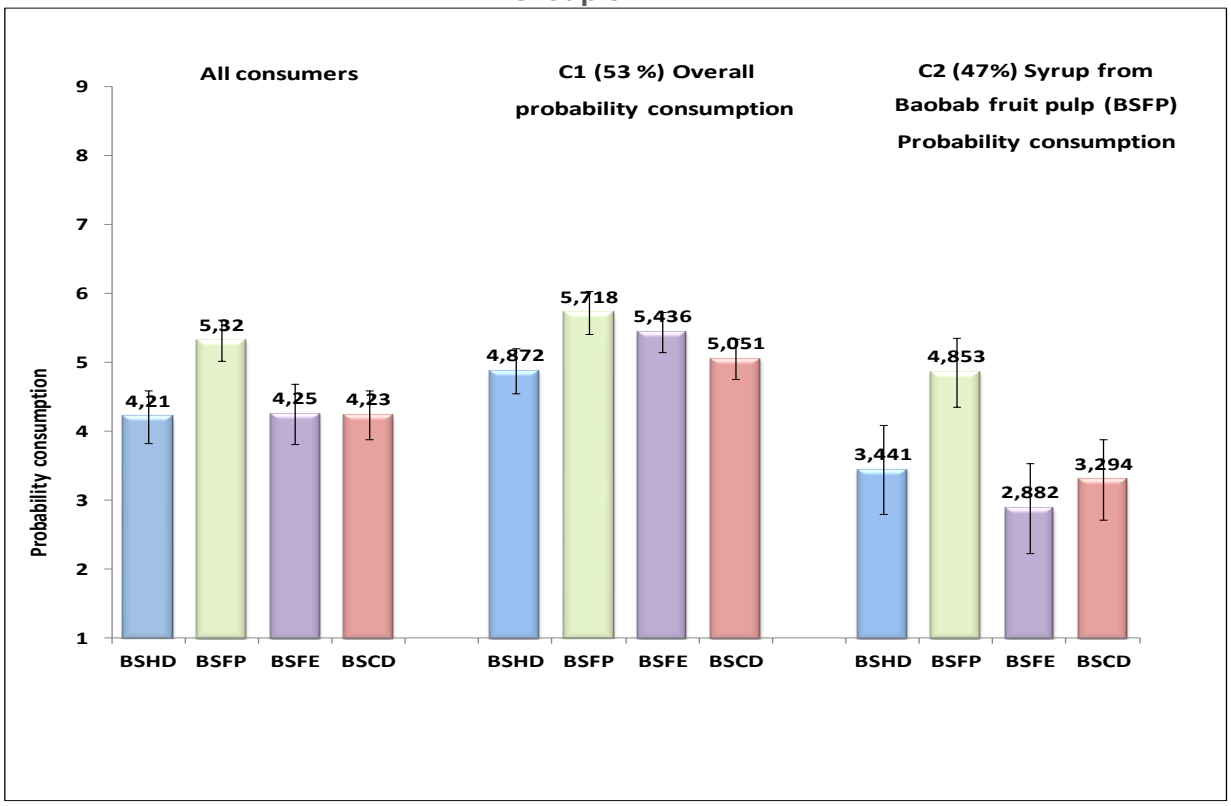


Figure 5 – Mean consumer Probability consumption of Baobab samples: syrup from Baobab power cold dissolution (BSCD); syrup from Baobab power hot dissolution (BSHD); syrup from Baobab fruit pulp (BSFP); syrup from Baobab fruit (Esteval) (BSFE).

*Error bars represent the confidence interval of the mean (p=0,95). Different superscripts within acluster indicate significant differences according Tukey's HSD ($p \leq 0,05$).

1.4.1.4 Evaluation of Intensity of sensory attributes relatively to participants' ideal level, using JAR scales: colour, sweet taste, acid taste and fruity taste.

Figure 6 shows the frequencies of intensity ratings, measured on a 3-point JAR scale, for each Baobab samples and sensory attribute evaluated (colour, sweet taste, acid taste and fruity taste).

A preponderance of JAR (Just-About-Right) ratings was observed for syrup from Baobab fruit pulp (BSFP) for the four attributes evaluated, with their frequencies ranging from 55% to 71%. This is well in line with overall liking results, which showed that BSFP was the preferred sample.

For all samples the sweet taste showed TS (Too strong) ratings above 40%, the sample considered more sweetness was syrup from Baobab power cold dissolution (BSCD) (51%). Respect to the fruity flavour and colour, the BSCD and syrup from Baobab power hot dissolution (BSHD) the TW (Too weak) ratings dominated for these two attributes, indicating that these samples have a lighter colour and less fruity flavour than

the remaining samples evaluated. The results for acid attribute showed for all samples a JAR between 56 and 71%, however from 26% to 36% of the participants indicated the TW ratings for these same attribute.

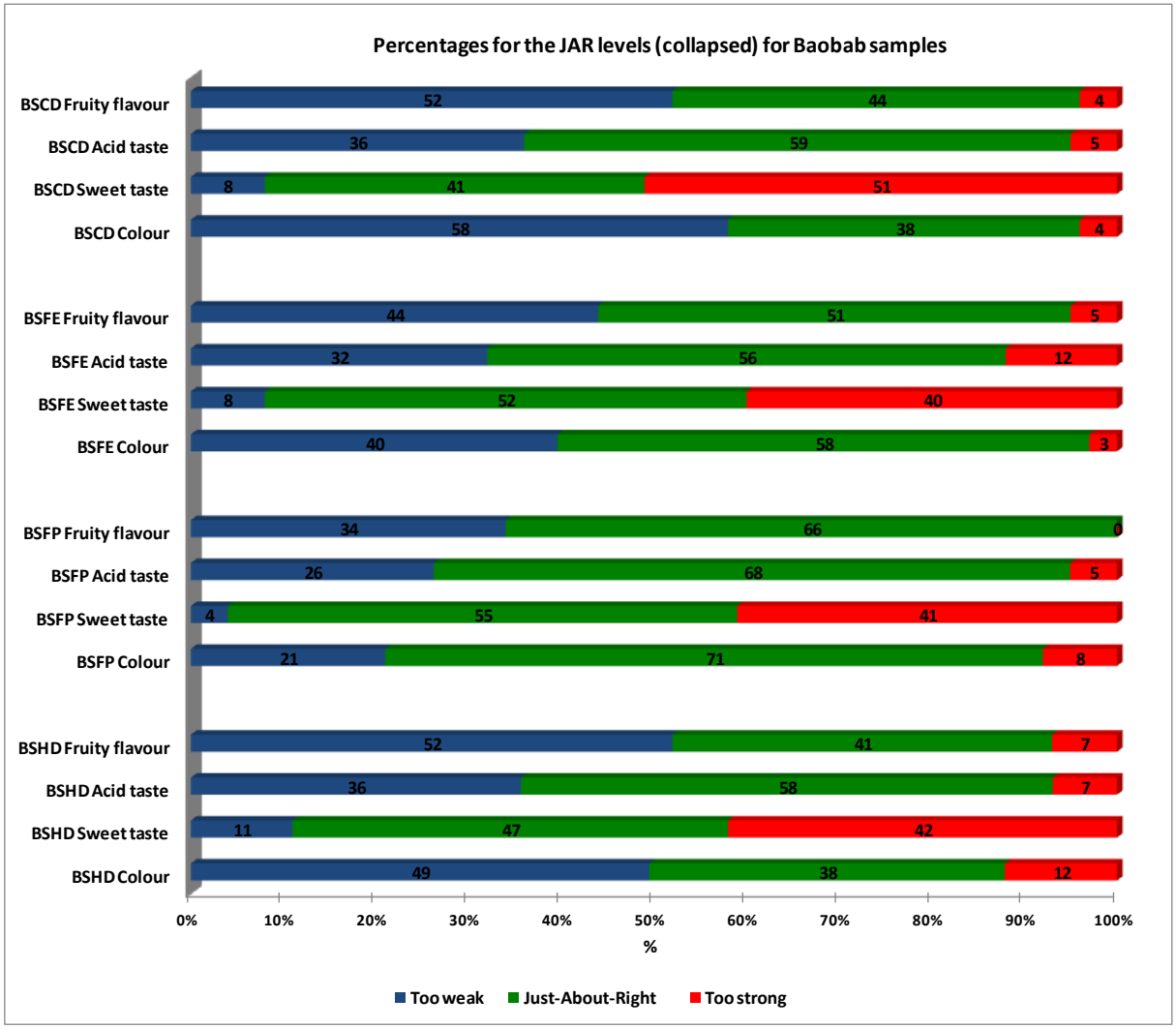


Figure 6 – JAR evaluations (%) for Baobab samples: syrup from Baobab power cold dissolution (BSCD); syrup from Baobab power hot dissolution (BSHD); syrup from Baobab fruit pulp (BSFP); syrup from Baobab fruit (Esteval) (BSFE).

With the purpose of identifying attributes which appear to have a stronger impact on overall liking, weighted penalties were calculated for all samples and attributes. The weighted penalties are represented in figure 7. Mean drops of 1.0 for nine-point overall liking scale and 20% respondents, are often considered the cut-off for a meaningful decline in acceptance related to a particular attribute, for this reason weighted penalties below 20 are usually considered negligible. All Baobab samples showed strong sweet

taste, however the sample that stood out was BSCD sample. For BSCD and BSHD a weak fruity flavour and colour were observed.

For the weighted penalty observed that the weak acid has a marked weight for all samples is in agreement with the results obtained for sweetness.

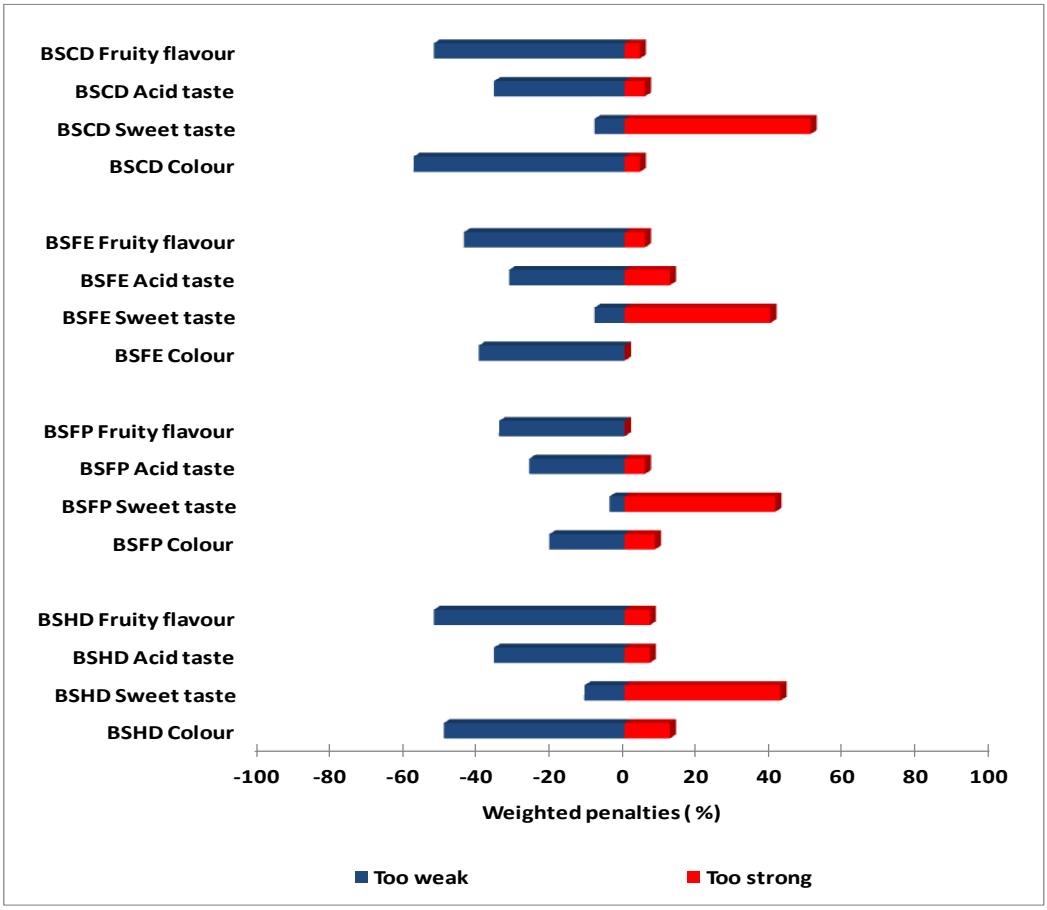


Figure 7 - Representation of the weighted penalty values relating overall liking ratings drops for each Baobab samples and attribute in relation with JAR attribute intensity ratings for all participants (n=73) for Baobab samples: syrup from Baobab power cold dissolution (BSCD); syrup from Baobab power hot dissolution (BSHD); syrup from Baobab fruit pulp (BSFP); syrup from Baobab fruit (Esteval) (BSFE).

1.4.1.5. Relating consumer acceptance measures and sensory profiling results

Principal component analysis (PCA) was performed considering the frequency of intensity ratings of the sensory attributes evaluated as active variables and overall liking and probability consumption ratings as supplementary variables.

The biplot represented in Figure 8 shows as syrup from Baobab fruit pulp (BSFP) was highly correlated to Overall liking and probability consumption, which reflects the results obtained in consumers test where consumers proved to be the preferred sample.

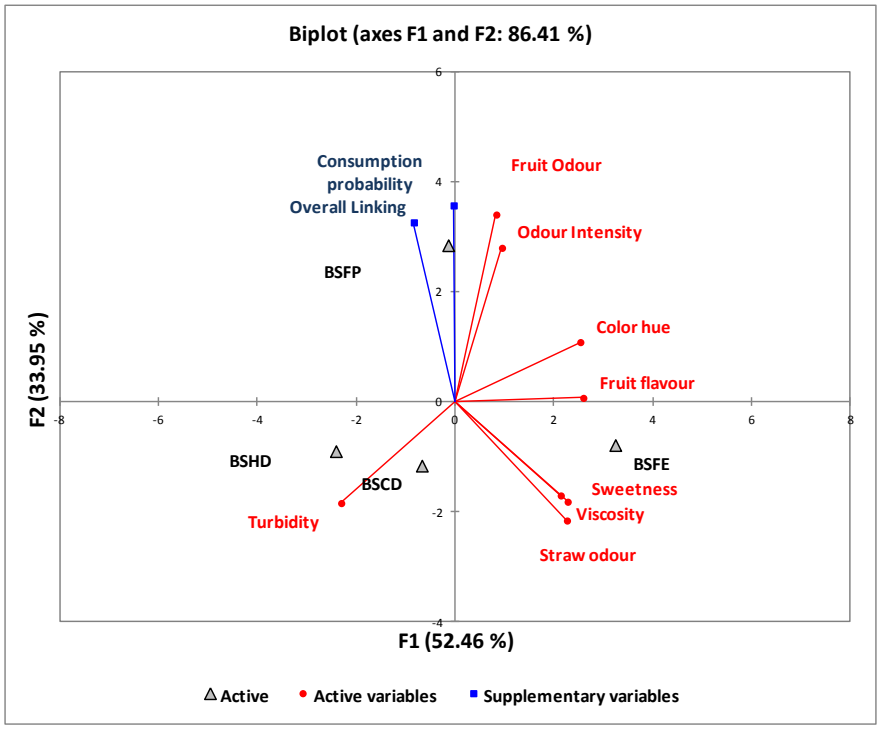


Figure 8 - Representation of the Baobab drinks and sensory attributes evaluated and overall liking and probability consumption in the two dimensions of a GPA analysis, performed on discriminating attributes. BSCD = Syrup from Baobab power cold dissolution; BSHD = Syrup from Baobab power hot dissolution; BSFP = Baobab fruit pulp (syrup); BSFE = Syrup from Baobab fruit (Esteval);

1.5 Conclusion

For Baobab fruit juices used in this consumer test, it was possible verify that all fruit juices were in the acceptable range since the average scores were between 5 (neither like nor dislike) and 7 (like moderately), which can be considered satisfactory taking into account that the Baobab is not commonly consumed in Portugal (and in Europe) and even unknown to the public. This type of drink due to its composition can be a great potential to be considered as functional beverage, which probably increases the interests of the consumer and market acceptance.

For the group of Baobab samples assessed the diluted from Syrup from Baobab fruit pulp (BSFP) showed to be most appreciated and obtained a positive value on the consumption probability. These results probably can be explained by the fact that

consumers associated more this sample with own Baobab fruit, since it has been the highest values in the fruit odour and intensity and colour hue. For all Baobab samples some common characteristics were observed namely very sweet and slightly fruity flavour and very light colour.

In the same questionnaires, some other marketing questions were included to understand the opportunity of Baobab in European market. These results were related with consumption habits of fruit juices, and were included in the report D.5.4.1 (Report on near-market consumer testing of new improved products and substitutes in Europe) where may be consulted. Moreover, the employment of overall liking assessments and JAR technique allow also to find important drivers for further sensory optimization of the Baobab samples to European market. Probably, for the European consumers these reengineering Baobab drinks should also be adjusted in terms of sweetness and acidity, as for the European habits are considered excessively sweet and low acidity.

2. Consumer preference study of Bissap reengineering products in Europe

2.1. Summary

Hibiscus calyces are fleshy, high on vitamin C, minerals, pectins, organic acids, polyphenols and anthocyanins and have a tart, cranberry-like flavour with high potential as functional drink prone to be accepted in Europe. In this deliverable the ultra-vacuum concentrate and the syrup obtained from reengineering were evaluated in Europe by comparable consumers' samples in France, Portugal and United Kingdom, along with a hibiscus infusion prepared freshly from ground dried calyces for baseline comparison. Consumer hedonic acceptance, Just-About-Right intensity evaluation of specific descriptors (JAR) and Check-All-That-Apply questions (CATA) were used to establish consumer's acceptance and sensory profile. In general, despite de high diversity of sensory characteristics, all the hibiscus drinks evaluated were in average positively appreciated by consumers, however new drinks were significantly more appreciated then the traditional infusion. Similar preference profiles were observed across countries although French participants were those that most appreciated the drinks. Clusters analysis performed showed new hibiscus drinks were liked slightly too moderately by participants in Clusters C1 (*Overall likers*) and C2 (*New drinks' likers*), which represented about 75% of participants in the study. Overall liking assessments were complemented by attribute intensity evaluations and sensory profiling to provide important insights about hibiscus drinks' perception and acceptability. The evaluation of the intensity of three sensory attributes - colour, sweet taste and acid taste -, relatively to participants' ideal level and it's relation with overall liking ratings, showed for REs a significant negative impact of the high sweetness on the drink overall liking. Oppositely for UVc the strong colour and acidity and weak sweetness led to a significant decrease in overall liking. CATA profiles were similar in the three countries, concerning both the actual drinks tested and an ideal theoretical drink. REs was perceived to have a highly distinct sensory profile when compared with FTi and UVc, and these with the described ideal drink.

In the case of REs although being the most appreciated drink, its high sweetness was an important penalizing factor in consumers acceptance as a drink, nevertheless other uses for this syrup can be foreseen. In the case of UVc drink where the strong character,

robust colour and strong acidity not so appreciated in Europe as in Senegal, could benefit European consumers' acceptance if we increase the dilution of the concentrate with an equilibrated degree of added sugar.

2.2. Introduction

The edible, deep crimson- or deep magenta-coloured calyces of the flowers of the *H. sabdariffa* var. *sabdariffa* race *ruber* (hereinafter referred to as *hibiscus*) are employed around the world in the (artisanal and industrial) production of foods, drinks, pharmaceuticals and cosmetics (Da-Costa-Rocha, Bonnlaender, Sievers, Pischel, & Heinrich, 2014; Ross, 2003). The fresh or dried hibiscus sepals have mainly culinary uses in traditional cuisines (e.g., in the preparation of hot and cold beverages, fermented drinks, jams, confectionary and desserts) (Cisse et al., 2009a; Ramírez-Rodrigues, Balaban, Marshall, & Rouseff, 2011; Sáyago-Ayerdi, Arranz, Serrano, & Goñi, 2007). Hibiscus calyces are fleshy, high on vitamin C, minerals, pectins, organic acids, polyphenols and anthocyanins (Cisse et al., 2009b; Sáyago-Ayerdi et al., 2007) and have a tart, cranberry-like flavour (Plotto, Mazaud, Röttger, & Steffel, 2004; Ross, 2003), being thus used around the world to prepare non-alcoholic drinks according to local recipes (Ramírez-Rodrigues et al., 2011). The consumption of sweetened, hot or cold hibiscus infusions – either as refreshment or folk remedy -, is very common in Asia, North-America and North-Africa (e.g., Sudan, Egypt) (Cisse et al., 2009a; Mohamed, Sulaiman, & Dahab, 2012; Morton, 1987). Still, it is nowhere more widespread that in West Africa, where dried hibiscus calices are found in every market and variations of ready-made or bottled hibiscus infusions are commonly sold on the streets (Bolade, Oluwalana, & Ojo, 2009; Cisse et al., 2009b; Plotto et al., 2004), as in Senegal where Hibiscus drinks are known as *jus de bissap* (Bolade et al., 2009; Cisse et al., 2009b).

Previous AFTER studies on the acceptability of traditional hibiscus drinks by Senegalese and European consumers' uncovered significant effects of plant variety and processing method, highlighting the importance of harmonizing the sensory profile of these drinks as part of the product re-engineering process and improving the product acceptability for Senegalese and European consumers. In view of this, three new hibiscus (50% Kor and 50% Vinto) drinks – an infusion, a syrup and a vacuum-concentrate were developed under AFTER project scope. These drinks were developed

at the *Laboratoire de Formation Continue en Industrie Agroalimentaire* of the *Ecole Supérieure Polytechnique* of *Univeersité Cheikh Anta Diop* (UCAD), in Dakar. Their manufacturing process was subsequently tested and scaled-up in the pilot plant of *Centre Sectoriel de Formation Professionnelle aux Métiers des Industries Agroalimentaires (CSFP IAA),* also in Dakar. The new drinks were prepared following an eco-efficient process, design to improve the preservation of nutritional quality and colour of the products while diminishing the production costs, by maximizing hibiscus calyces' s extraction efficiency and diminishing pasteurization temperature and production time.

The sensory quality of these three new drinks was evaluated, alongside a traditional infusion prepared by a local producer (baseline), by Senegalese consumers in Dakar in the fall of 2013 (Deliverable D5.5.2.3). The most appreciated drinks, the ultra-vacum concentrate and the syrup, were later evaluated in Europe by comparable consumers' samples in France, Portugal and United Kingdom, along with a hibiscus infusion prepared freshly from ground dried calyces for baseline comparison. Consumer hedonic acceptance, Just-About-Right intensity evaluation of specific descriptors (JAR) and Check-All-That-Apply questions (CATA) were used to establish consumer's acceptance and sensory profile.

2.3. Material and Methods

2.3.1. Samples and sample preparation

Three hibiscus drinks were tested, a hibiscus infusion prepared freshly from dried calyces according to Senegalese recipe for baseline comparison (FTi) and two new hibiscus drinks developed under the AFTER project scope – an ultra-vacuum concentrate (UVc) and improved syrup (REs). All drinks were produced from ground dried calyces of the local 'Koor' and the Sudanese 'Vimto' *H.* var. *sabdariffa* cultivars (50:50), purchased at Latmingue – Kaolack.

The hibiscus infusion (FTi) was freshly prepared with 30 g of calyces soaked in 1 liter of boiling water. After 20 minutes the resulting extract was filtered, sweetened with sucrose (130 gL^{-1} and kept refrigerated until used.

The new syrup (REs) was obtained using a ratio of 1/10 dried hibiscus calices/water and 30 min extraction time at ambient temperature. The resulting infusion was filtered at 0.45 µm and pasteurized at 75ºC during 20min. Sucrose was added (1.2 kg/L, until approximately 65°Brix), the syrup was cooled down immediately, it was bottled as the product reached a temperature of 70°C and stored at room temperature.

The Under-vacuum concentrate (UVc) was obtained employing a similar process of REs, using a ratio of ground calices/water of 1/5 (w/v) and 30 min extraction time at ambient temperature. The filtered extract (0.45 µm) was pasteurized at 75ºC for 20 minutes, subsequently evaporated under-vacuum at 75 °C and remained unsweetened. Upon cooling to ambient temperature, the concentrate was stored at 4 to 8°C.

The REs sample was diluted 4 times with potable water prior to tasting. The UVc concentrate was diluted 40 times with potable water and sweetened with sucrose (130 gL^{-1}).

2.3.2. Ethical assessment and consent

The study was reviewed by project AFTER's Ethics Committee. Participants were informed about the study's general aim and procedures for handling personal data, and gave written informed consent prior to participating in the tasting sessions. All tested samples were produced and prepared according to good hygiene and manufacturing practices. The new drinks tested resulted mainly from incremental changes in the traditional manufacturing processes, with the aim of better extracting and preserving its nutritional value while increasing its eco-efficiency. No safety or health concerns were introduced by such changes.

2.3.3. Participants

Participants were non-probabilistically recruited in France (Montpellier, n=143, Portugal (Porto, n=134) and United Kingdom (Rochester, n=128), according to their willingness and availability to participate in the study. All participants consumed fruit beverages and 95% consumed fruit beverages or cold tisanes at least monthly, 98% were European or European residents, their ages ranged between 18 and 72 years old (average 31.1, standard deviation 12.2) and 52% were women. Less than 3% of participants were frequent hibiscus products consumers, 19% of participants consumed

hibiscus products occasionally and 22% seldom, 56% of participants stated they had never consumed hibiscus products or were not sure to have ever consumed them.

2.3.4. Tasting sessions

Tasting sessions took place at each of the three aforementioned cities. The questionnaire was written in French, Portuguese and English and included questions about consumption of fruit beverages and tisanes, socio-demographic and attitudinal variables. Qualtrics online survey software was used (Qualtrics, LLC.) To gather evaluative relevant information and maximize the equivalence between questionnaires, exploratory local focus groups were performed.

Thirty millilitre samples of each of the hibiscus drinks tested were served in clear plastic glasses, following a complete balanced experimental plan. Each sample was identified by a random code with 3 digits. Water was supplied to clean the palate between tastings. Participants were informed the samples were non-alcoholic beverages and no other information was provided except for safety considerations. Questions related with hibiscus products consumption and red fruits beverages consumption were asked to participants only after the completion of the sensory related questions.

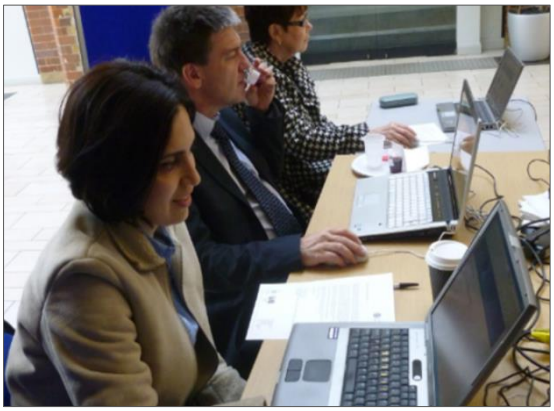


Figure 1 – Tasting sessions in NRI

Figure 2 – Tasting sessions in CIRAD

Figure 3 – Sample presentation

2.3.5. Consumer acceptance measures

Consumer acceptance was measured by overall liking ratings, provided on a 9-point hedonic scale (Jones, Peryam, & Thurstone, 1955; Peryam & Girardot, 1952; Peryam & Pilgrim, 1957). The intensity of three sensory attributes – *colour*, *sweet taste* and *acid taste* -, relatively to participants' ideal level, was measured by ratings provided on a 3-point, just-about-right scale [*too weak* (TW), *just-about-right* (JAR), *too strong* (TS)].

2.3.6. Consumer sensory profiling

Sensory profiles were obtained for each sample by employing check-all-that-apply (CATA) questions (Adams, Williams, Lancaster, & Foley, 2007; Ares, Barreiro, Deliza, Giménez, & Gámbaro, 2010). These entailed 24 sensory or hedonic-oriented descriptors – *light red*, *dark red*, *red fruits*, *simple*, *antioxidant*, *tisane*, *acidic*, *bitter*, *sweet*, *astringent*, *syrup*, *floral*, *invigorating*, *watery*, *balanced flavour*, *strong taste*, *fruity*, *natural*, *different/unknown*, *refreshing*, *artificial*, *healthy*, *high calorie* and *new* -, drawn

from previous focus groups held in Senegal (n=20, 55% men, 18-70 years old) and Portugal (n=22, 54% men, 18-75 years old). The order of presentation of descriptors was randomized across subjects. Additionally, participants were asked to use CATA question to describe their ideal beverage (ID).

2.3.7. Statistical analysis

XLSTAT software (Addinsoft SARL, France) and IBM SPPS Statistics, Version 22.0 (IBM Corp., USA) were used to carry out all statistical analyses. The significance of statistical tests was evaluated at $p<0.05$, unless otherwise mentioned.

2.3.7.1.Preliminary data analysis

For this study were considered participants within the range of 18 years to 75 years old. Responses from participants with very low frequencies of consumption of fruit beverages and cold beverages from plant extracts (below rarely) were excluded from further analysis.

In France, atypical overall liking ratings were observed for two participants for FTi sample ($p< 0.005$) and one participant for UVc sample ($p< 0.001$). The responses of these three participants were hence excluded from further analysis.

The resulting number of participants was 133 for Portugal, 124 for United Kingdom and 133 for France.

2.3.7.2.Consumer acceptance measures

Analysis of Variance (ANOVA) was performed on overall liking ratings for the three samples, considering participants and samples as sources of variation. Mean sample ratings were calculated and significant differences between them tested post-hoc using Tukey's HSD (Honest Significant Difference) tests. Pair-wise Pearson correlations between samples' overall liking ratings were then computed to assess their degree of association.

Hierarchical cluster analysis (Euclidean distances and Complete linkage agglomeration method) was subsequently performed to identify groups of participants with dissimilar patterns of sample liking. Analysis of Variance (ANOVA) was performed on within-clusters' overall liking ratings for the four samples, considering participants and samples as sources of variation. Within-cluster mean sample ratings were calculated and

significant differences between them tested post-hoc using Tukey's HSD tests. The existence of significant differences between clusters' mean ages was assessed using Student's t-tests. Finally, the existence of significant differences between clusters' gender proportions was evaluated by Pearson's chi-square tests with Monte Carlo procedure.

The frequency of intensity ratings (TW, JAR, TS) for each of the three sensory attributes evaluated by participants was determined for each sample, and the corresponding proportions calculated. A Correspondence Analysis (CA) was then performed on the contingency table of proportions for all samples and attributes (Popper, 2014). The frequency of intensity ratings for each sample and attribute was finally tallied for each cluster of participants based on overall liking ratings.

A penalty analysis (Popper, 2014) was employed to relate attribute intensity ratings to overall liking ratings for each participant and sample. To this end, participants were grouped according to their intensity ratings for each sample and attribute, and mean overall liking ratings for each group were computed. The overall liking mean drops, or penalties, obtained when comparing the TW and the TS group with JAR participants were then calculated. Weighted penalties (Popper, 2014) were equally computed by taking both the mean drops and the proportion of participants in each group.

2.3.7.3.Consumer Sensory profiling

The frequency with which each of the 24 descriptors was checked by participants for each sample plus the ideal drink was tallied and the corresponding proportions calculated. To investigate which descriptors were more frequently co-elicited across samples, a Multidimensional Scaling (MDS) procedure were applied to the chi-square distances' matrix of descriptors (Meyners & Castura, 2014). A Cochran's Q test was performed for each descriptor, followed by the computation of multiple pair-wise comparisons with the Marascuilo procedure, to assess the extent to which it discriminated between samples (Meyners & Castura, 2014; Meyners, Castura, & Carr, 2013). To obtain a bi-dimensional representation of CATA results a CA was performed (Meyners & Castura, 2014) for descriptors discriminating significantly ($p<0.05$) between samples, ideal drink included.

A penalty-lift analysis (Williams, 2011) was employed to relate participants' choices of descriptors for each hibiscus drink evaluated to the corresponding overall liking ratings.

To this end, sample overall liking ratings were averaged across all participants for which the descriptor under consideration was elicited and for which it was not. A positive penalty-lift was obtained when the former was higher than the later and negative penalty-lift when the reversed occurred.

2.3.7.4. Relating consumer acceptance measures and sensory profiling results

A multiple factor analysis (MFA) was performed (Ares, Varela, Rado, & Giménez, 2011), considering overall liking ratings, the frequency of intensity ratings of the sensory attributes evaluated and the frequency of choice of discriminating CATA descriptors, across all samples and participants, as active variables.

2.4. Results and discussion

2.4.1. Consumer acceptance, overall liking ratings

Table 1 depicts the mean overall liking ratings for all countries for the three hibiscus drinks tested. These were higher than 5.50 out of 9 points for all samples, which indicates that participants, on average, positively appreciated them. Highly significant associations between overall liking ratings and participants' age were observed for UVc ($p=0.02$) and FTi ($p=0.01$), with overall liking increasing with age. Overall liking ratings of UVc, REs and FTi were highly significantly correlated ($p<0.001$).

Table 1 – Overall liking ratings of hibiscus drinks (n=390).

Sample	Overall liking ratings
REs	$6.51^{a} \pm 0.15$
UVc	$5.98^{b} \pm 0.19$
FTi	$5.63^{c} \pm 0.21$

Mean ± confidence interval of the mean (95%). Different superscripts indicate significant differences according to Tukey's HSD ($p<0.05$). UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion.

Similar preference profiles were observed across countries as shown in Figure 4, however slightly higher results were obtained in France. Mean overall liking ratings of 5.5 out of 9 were obtained for all countries for the improved hibiscus drinks (UVc and FTi) but not for the traditional infusion.

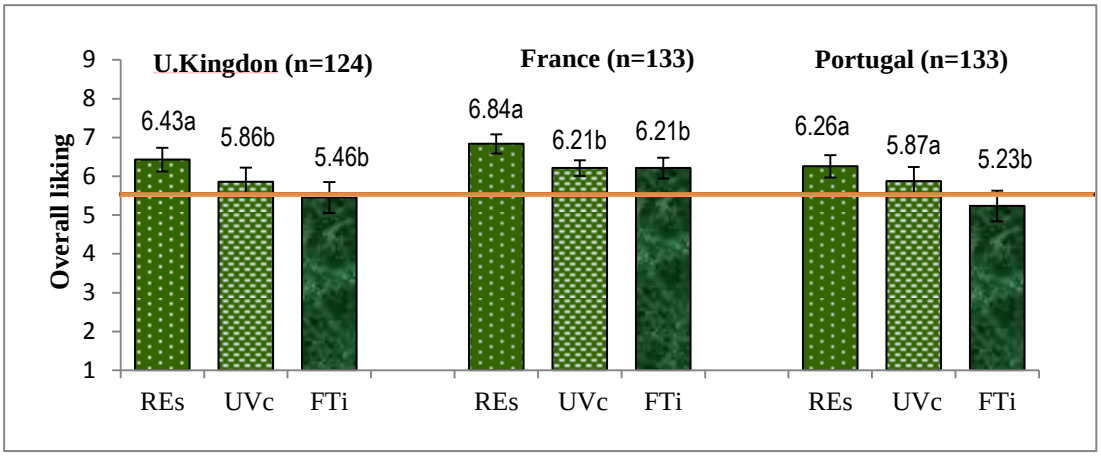


Figure 4 - Means of the overall liking ratings of hibiscus drinks per country. Different superscripts within a cluster indicate significant differences according Tukey's HSD ($p<0.05$). UVc=under-vacuum concentrate; RES=improved syrup; FTi= prepared infusion.

Hierarchical clustering yielded three clusters of participants with distinct overall liking patterns of hibiscus drinks, as depicted in Figures 5 and 6. The clusters identified were: *Overall likers* (C1;51%) - who liked all the tested drinks slightly to moderately, *New drinks likers* (C2;24%) who liked the new concentrate and syrup slightly to moderately but disliked the prepared infusion and finally the *Syrup likers* (C3;25%) who slightly liked REs but disliked both UVc and FTi. No significant differences between clusters related with countries and gender were observed. However significant differences were detected for age ($p<0.01$), with participants of cluster 3 (Syrup likers) being younger than participants in the other clusters (Mean age - C1:$\bar{X}$=32.2, C2:$\bar{X}$=32.5. C3:$\bar{X}$=27.4). Cluster analysis per country yielded similar patterns of acceptance across countries

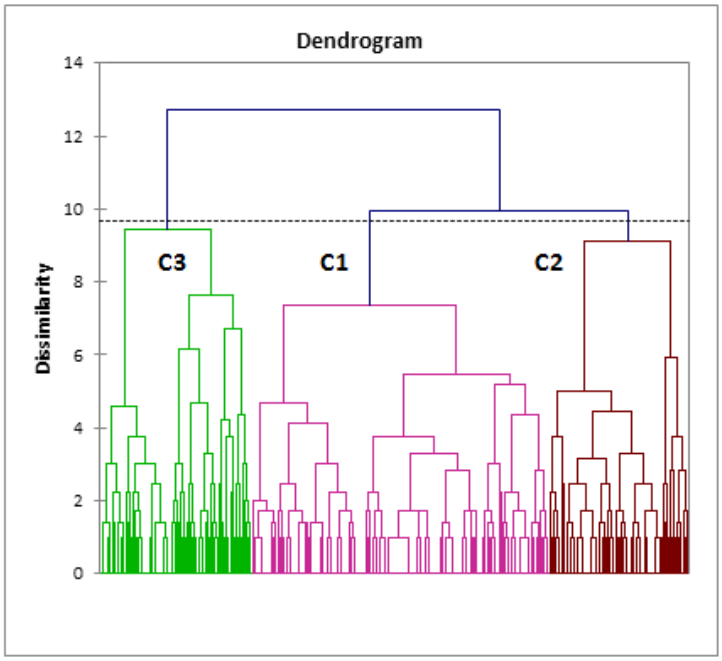


Figure 5 – Hierarchical clustering dendogram segmenting participants according to their overall liking patterns of hibiscus drinks (n=390).

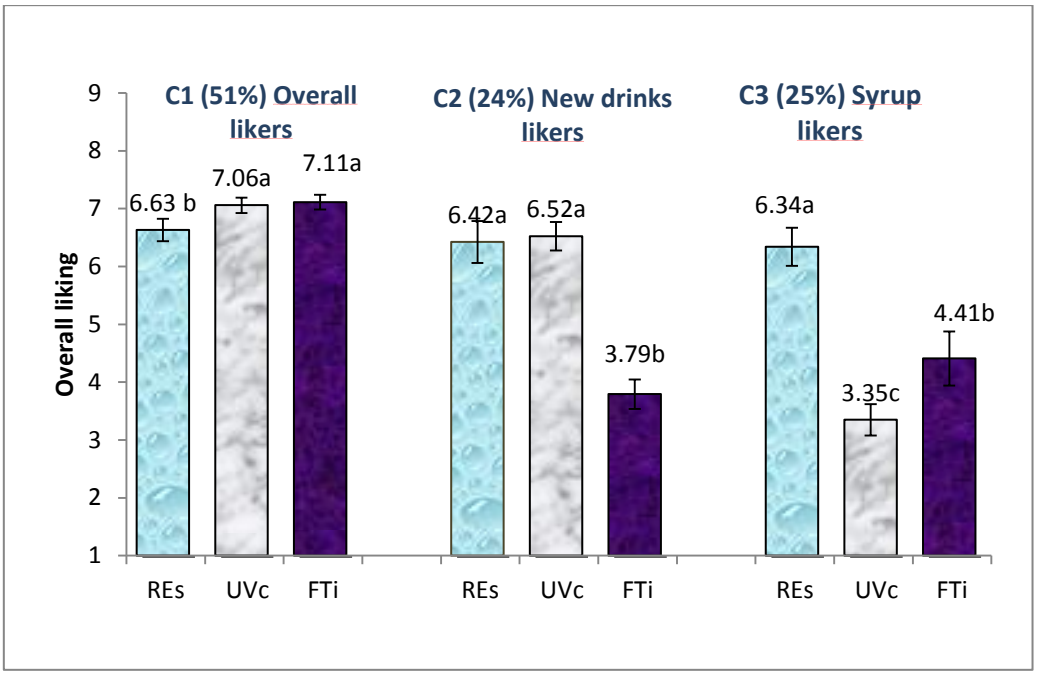


Figure 6 - Means of the overall liking ratings of hibiscus drinks per cluster for all participants (n=390). Error bars represent confidence intervals of means (p=0.95). Different superscripts within a cluster indicate significant differences according Tukey's HSD ($p<0.05$). UVc=under-vacuum concentrate; RES=improved syrup; REi=improved infusion; FTi=prepared infusion.

2.4.2. Evaluation of Intensity of sensory attributes relatively to participants' ideal level, using JAR scales : colour, sweet taste and acid taste

Similar results were observed in all countries for all samples and attributes. Figure 7 depicts the first two dimensions of the CA performed on the 3-point JAR ratings for each hibiscus drink and sensory attribute evaluated for all participants. It shows a preponderance of just-about-right ratings for REs colour, whereas the UVc colour was rated predominantly as too strong. For sweetness and acidity UVC and FTi were predominantly rated as too strong in acidity and too weak in sweetness, whereas for REs the opposite was observed.

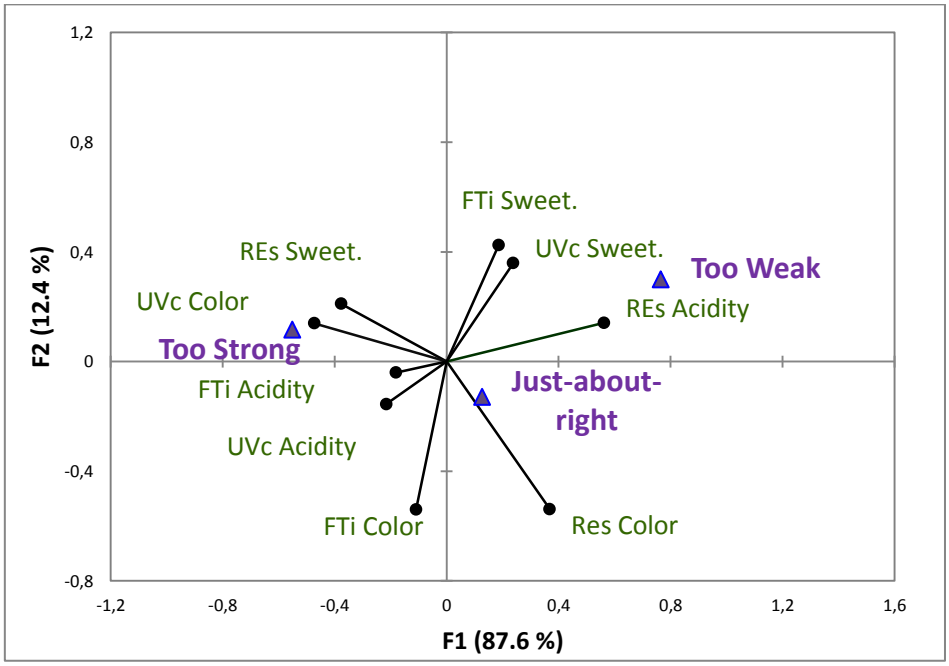


Figure 7 - Representation of the hibiscus drinks and sensory attributes evaluated in the first two dimensions of a correspondence analysis, performed on attribute intensity ratings measured on a 3-point just-about-right scale [too weak (TW), just-about-right (JAR), too strong (TS)] for all participants (n=390). UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion.

With the purpose of identifying attributes which appear to have a strong impact on overall liking, weighted penalties were calculated for all samples and attributes. The weighted penalties are represented in figure 8. Mean drops of 1.0 for nine-point overall liking scale and 20% respondents, are often considered the cut-off for a meaningful decline in acceptance related to a particular attribute, for this reason weighted penalties below 20 are usually considered negligible. For REs a significant impact of the high

sweetness was observed. Oppositely for UVc and the FTi strong colour acidity and weak sweetness led to a significant decrease in overall liking.

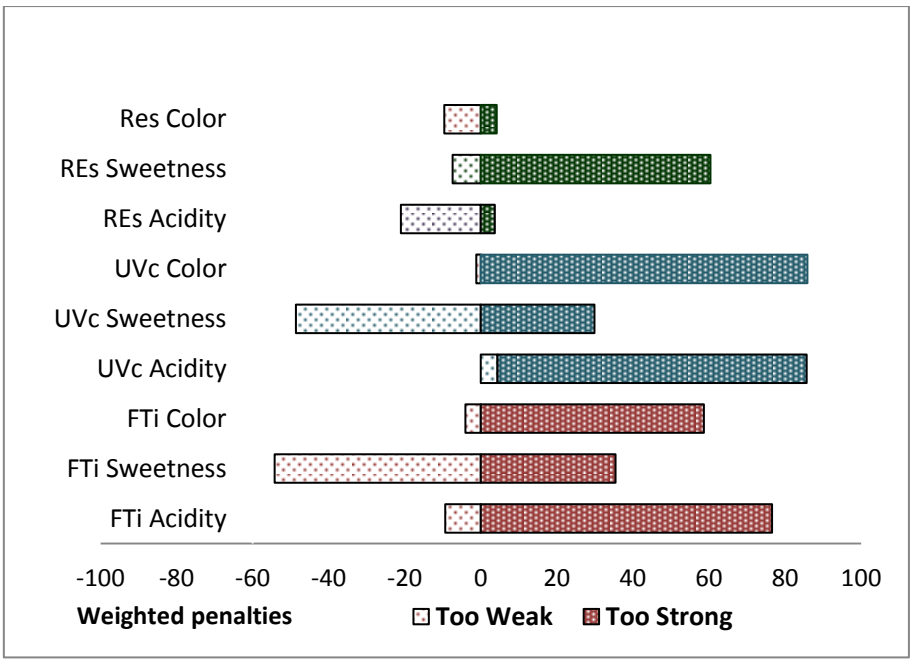


Figure 8 - Representation of the weighted penalty values relating overall liking ratings drops for each sample and attribute in relation with JAR attribute intensity ratings for all participants (n=390). UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion.

2.4.3. CATA profiling

The CATA terms used were: acid, bitter, astringent, strong taste, balanced flavour natural, fruity, syrup, light red, dark red, tisane, floral, sweet, artificial, refreshing, new, healthy, invigorating, red fruits, simple, watery, different/unknown, high calorie, antioxidant.

Participants used between 1 and 15 CATA question terms to describe the three evaluated drinks and their ideal beverage with an average of five terms per drink. Significant differences in descriptors' frequencies between hibiscus samples were found for 9 descriptors in PT, 11 for UK and 12 in FR ($p<0.05$), as shown in table 2. The terms red fruits and new were non-discriminating in all countries for all drinks including the ideal drink. The terms balanced flavor, artificial, healthy, natural, refreshing, invigorating, antioxidant and simple were non-discriminating for the three evaluated drinks but significant frequencies of elicitation were used to describe the ideal drink. Tisane and new were among the less frequently chosen terms, suggesting consumers in

general did not recognize the drink as an extract of an unknown plant. Oppositely the most frequently chosen terms were fruity and red fruits suggesting participants misidentified the drinks as red fruits beverages.

The first three dimensions of the Multidimensional scaling (MDS) representation determined on chi-square distances of CATA descriptors for all participants is represented in figure 9 uncovering relationships between descriptors and indirectly with samples' profiles. It shows that attributes astringent, bitter, acid, dark red and strong taste were frequently co-elicited by participants, in a smaller degree they were also co-elicited with the attributes new, red fruits and different/unknown. Natural, invigorating and healthy were also frequently coelicited as were high calorie and syrup and finally watery and sweet. As expected, contrasting attributes like healthy and artificial or healthy and high calorie seemed to be rarely selected together.

Table 2 - Frequency of selection for each descriptor by consumers (Check-All-That-Apply method).

	PT				FR				UK			
CATA descriptors	UVc	REs	FTi	ID	UVc	REs	FTi	ID	UVc	REs	FTi	ID
Light red	1 a	37 b	5 a	25 b	1a	55c	10a	31b	4a	36b	13a	17a
Sweet	39 a	96 b	32 a	45 a	37a	106b	54a	43a	33a	82b	38a	40a
Dark red	100 c	30 a	70 b	26 a	79c	6a	33b	18ab	70b	19a	51b	17a
Astringent	18 b	4 a	20 b	5 a	32b	6a	40b	3a	14b	2a	11b	3a
Strong taste	73 b	32 a	77 b	20 a	40bc	19a	51c	26ab	61b	34a	64b	24a
Syrup	36 b	59 c	39 b	2 a	20b	61c	23b	2a	21b	52c	22b	4a
Acid	60 c	4 a	54 c	25 b	65c	6a	58c	28b	49b	6a	45b	11a
Bitter	27 b	1 a	39 b	2 a	9ab	1a	17b	1a	39b	6a	48b	4a
High calorie	16 b	24 b	9 a	1 a	8ab	28c	14b	1a	10b	16b	7ab	0a
Watery	8 a	16 a	13 a	10 a	6a	21b	5a	2a	7a	23b	13ab	15ab
Tisane	6 a	8 a	17 a,b	28 b	2a	4a	16b	5a	1a	0a	4a	2a
Floral	16 a	15 a	21 a	18 a	14a	32b	35b	29b	10a	19ab	24ab	16ab
Fruity	58 a	75 a,b	56 a	88 b	53a	65a	59a	97b	55ab	68bc	40a	87c
Natural	20 a	20 a	17 a	101 b	26a	21a	24a	102b	21a	18a	17a	89b
Refreshing	31 a	33 a	28 a	115 b	47a	56a	46a	111b	26a	32a	25a	101b
Invigorating	9 a	11 a	11 a	55 b	20a	14a	27a	52b	8a	10a	12a	35b
Artificial	22 b	24 b	24 b	0 a	21b	24b	23b	0a	21b	24b	24b	2a
Balanced flavour	28 a	26 a	16 a	110 b	28a	22a	21a	90b	21a	25a	16a	75b
Antioxidant	53 a	49 a	48 a	72 b	21a	12a	19a	40b	16a	8a	16a	44b
Healthy	20 a	20 a	20 a	111 b	11a	4a	14a	84b	20a	17a	10a	77b
Simple	6 a	15 a	4 a	33 b	9a	13a	5a	0a	10a	18a	5a	38b
Different/Unknown	27 b	31 b	31 b	6 a	17ab	15ab	26b	10a	6a	14ab	19b	10ab
Red fruits	87 a	85 a	78 a	70 a	66a	66a	62a	57a	49a	53a	48a	40a
New	27 a	22 a	24 a	16 a	21a	21a	25a	27a	13a	10a	16a	9a

For each country, different letters within a line indicate significant differences according to Cochran's Q-test with Marascuilo pairwise comparisons ($p<0.05$). UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion.

Figure 9 – Representation of the multidimensional scaling of all CATA descriptors frequencies for all participants (n=390) and drinks (UVc, REs, FTi, ID) based on chi-square distances.

The first two dimensions of the Correspondence Analysis performed on discriminating terms explained 96.3% of the variability as shown in figure 10. CA biplot showed that REs was perceived to have a highly distinct sensory profile when compared with FTi and UVc. While REs was attributed with mild descriptors (sweet, watery, syrupy and light red), UVc and FTi were related to more aggressive ones (strong taste, acidic, bitter, astringent, dark red). ID was mainly described using non-sensory descriptors, emotional and hedonic terms like healthy, natural, refreshing, invigorating and antioxidant and balanced flavour. The descriptors tisane, simple and fruity although not well represented in the CA biplot were, nevertheless, mainly associated with ID.

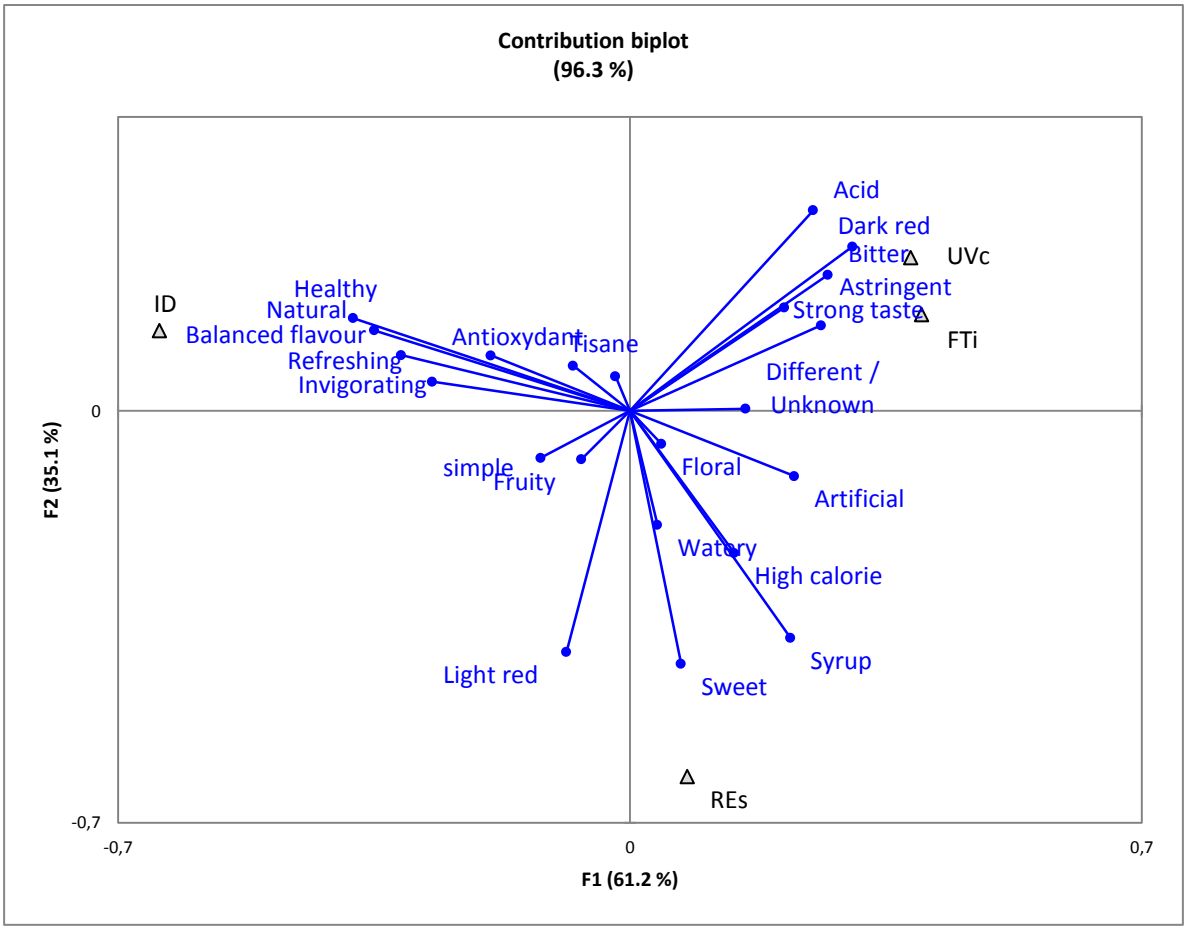


Figure 10 - Representation of the hibiscus drinks and sensory attributes evaluated in the first two dimensions of a correspondence analysis, performed on CATA discriminating terms for all participants (n=390). UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion; ID=ideal drink.

2.4.4. Relationship between CATA, JAR and Hedonic Overall appreciation

A Multiple Factor Analysis (MFA) was used to relate consumer's overall liking ratings, JAR ratings and CATA terms frequency of elicitation, for the three evaluated drinks and all consumers. The two first dimensions of the MFA projective mapping data of the samples and centroids are represented in Figure 11, corresponding to 94.3% of the explained variability. It shows a good differentiation among drinks and good agreement between appropriateness evaluations using JAR scales and CATA evaluations for all Hibiscus drinks.

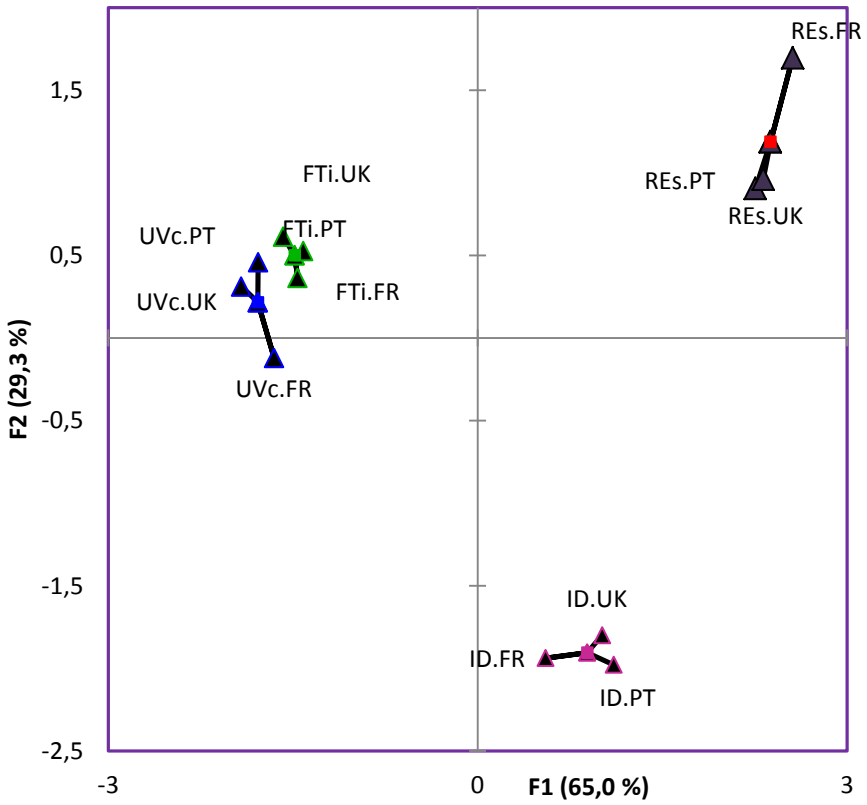


Figure 11 – Partial representation of Hibiscus drinks in the first two dimensions of MFA analysis of CATA descriptors, attribute intensity ratings measured on a 3-point just-about-right scale and overall liking scores. UVc=under-vacuum concentrate; RES=improved syrup; FTi=prepared infusion.

2.5. **Conclusions**

In spite of their varying sensory characteristics, all the hibiscus drinks evaluated were in average positively appreciated by consumers. Similar preference profiles were observed across countries although French participants were the ones that appreciated the drinks the most. The new drinks developed under AFTER scope were significantly more appreciated then the traditional infusion freshly prepared from dried hibiscus calices used as baseline comparison. Clusters analysis performed showed new hibiscus drinks were liked slightly too moderately by participants in Clusters C1 (*Overall likers*) and C2 (*New drinks' likers*), which represented about 75% of participants in the study. Overall liking assessments were complemented by attribute intensity evaluations and sensory profiling to provide important insights about hibiscus drinks' perception and acceptability. The evaluation of the intensity of three sensory attributes - colour, sweet taste and acid taste -, relatively to participants' ideal

level and it's relation with overall liking ratings, showed for REs a significant negative impact of the high sweetness on the drink overall liking. Oppositely for UVc the strong colour and acidity and weak sweetness led to a significant decrease in overall liking. These results were in accordance with the ones obtained on CATA-derived sensory profiles. CATA profiles were similar in the three countries, concerning both the actual drinks tested and an ideal theoretical drink. REs was perceived to have a highly distinct sensory profile when compared with FTi and UVc, and these with the described ideal drink. CATA results also suggested also that most consumers did not recognize the tested drink as an extract of an unknown plant, hibiscus and misidentified it as a red fruits beverage.

Important drivers for further sensory optimization of the new hibiscus drinks were uncovered through the employment of JAR, CATA and overall liking assessments.

In the case of REs although being the most appreciated drink, its high sweetness was an important penalizing factor in consumers acceptance as a drink, nevertheless other uses for this syrup can be foreseen (flavoring hot and cold teas, cocktails, yogurts and other fermented dairy and non-dairy products, smoothies, frozen desserts and others) where it's strong sweetness might have a positive impact on consumers evaluation. UVc drink was prepared following the same dilution used in the previous study held in Senegal, where hibiscus drinks are very popular and consumers are used to their strong character, robust colour and strong acidity, therefore the usage of a bigger dilution of the concentrate to prepare the drink while maintaining an equilibrated degree of added sugar can lead to a significant improvement of consumers' acceptance.

Besides exploring further opportunities for enhancing the sensory profiles of the new drinks in line with European taste, future studies should also investigate the levels of marketing activities (pricing, distribution and promotional information – including nutritional and healthiness attributes) which will best support their successful introduction in European markets.

2.6. Acknowledgement

This publication is an output from a research project funded by the European Union (FP7 245–025) called African Food Revisited by Research (AFTER - http://www.after-fp7.eu/),with additional financial support and FCT (Fundação para a Ciência e a Tecnologia) – PEst OE/EQB/LA0016/2013.The views expressed are not necessarily those of the European Union.

2.7. References

Arnold, T.H., Wells, M.J., Wehmeyer, A.S. *Khoisan food plants: taxa with potential for future economic exploitation.* In: *Plants for Arid Lands*, Wickens, G.E.; Goodin, J.R.; Field, D.V. (eds.), Allen and Unwin, London, UK, 69-86: 1985.

Adams, J., Williams, A., Lancaster, B., & Foley, M. (2007). Advantages and uses of check-all-that-apply response compared to traditional scaling of attributes for salty snacks. Paper presented at the 7th Rose-Marie Pangborn Sensory Science symposium, Minneapolis, MN, USA.

Ares, G., Barreiro, C., Deliza, R., Giménez, A. N. A., & Gámbaro, A. (2010). Application of a check-all-that-apply question to the development of chocolate milk desserts. Journal of Sensory Studies, 25(Ss1), 67-86. doi: 10.1111/j.1745-459X.2010.00290.x

Ares, G., Varela, P., Rado, G., & Giménez, A. (2011). Are consumer profiling techniques equivalent for some product categories? The case of orange-flavoured powdered drinks. International Journal of Food Science & Technology, 46(8), 1600-1608. doi: 10.1111/j.1365-2621.2011.02657.x

Bolade, M. K., Oluwalana, I. B., & Ojo, O. (2009). Commercial practice of roselle (Hibiscus sabdariffa L.) beverage production: Optimization of hot water extraction and sweetness level. World Journal of Agricultural Sciences, 5(1), 126-131.

Cisse, M., Dornier, M., Sakho, M., MarDiop, C., Reynes, M., & Sock, O. (2009a). La production du bissap (Hibiscus sabdariffa L.) au Sénégal. Fruits, 64(2), 111-124. doi: 10.1051/fruits/2009006

Cisse, M., Dornier, M., Sakho, M., Ndiaye, A., Reynes, M., & Sock, O. (2009b). Le bissap (Hibiscus sabdariffa L.) : composition et principales utilisations. Fruits, 64(3), 179-193. doi: 10.1051/fruits/2009013

Da-Costa-Rocha, I., Bonnlaender, B., Sievers, H., Pischel, I., & Heinrich, M. (2014). Hibiscus sabdariffa L. – A phytochemical and pharmacological review. Food Chemistry, 165, 424-443. doi: 10.1016/j.foodchem.2014.05.002

Jones, L. V., Peryam, D. R., & Thurstone, L. L. (1955). Development of a scale for measuring soldiers' food preferences. *Journal of Food Science, 20*(5), 512-520. doi: 10.1111/j.1365-2621.1955.tb16862.x

Gruenwald, J.; Galizia, M. In *Adansonia digitata L. Baobab*, United Nations Conference on trade and development, 2005; UNCTAD /DITC/TED: 2005.

Jones, L. V., Peryam, D. R., & Thurstone, L. L. (1955). Development of a scale for measuring soldiers' food preferences. Journal of Food Science, 20(5), 512-520. doi: 10.1111/j.1365-2621.1955.tb16862.x

Meyners, M., & Castura, J. C. (2014). Check-All-That-Apply questions. In P. Varela & G. Ares (Eds.), Novel Techniques in Sensory Characterization and Consumer Profiling (pp. 271-305). Boca Raton: CRC Press

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. Food Quality and Preference, 30(2), 309-319. doi: 10.1016/j.foodqual.2013.06.010

Mohamed, B. B., Sulaiman, A. A., & Dahab, A. A. (2012). Roselle (Hibiscus sabdariffa L.) in Sudan, cultivation and their uses. Bulletin of Environment, Pharmacology and Life Sciences 1(6), 48-54.

Morton, J. F. (1987). Roselle. In C. F. Dowling (Ed.), Fruits of warm climates (pp. 281-286). Greensborough, NC: Media Incorporated

Nour, A. A.; Magboul, B. I.; Kheiri, N. H., Chemical composition of baobab fruit (Adansonia digitata L.). *Tropical Sciences* **1980,** 22, 383-388.

Peryam, D. R., & Girardot, N. F. (1952). Advanced taste-test method. Food Engineering, 24(7), 58-61.

Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences. *Food Technology*, *11*(Suppl.), 9-14.

Plotto, A., Mazaud, F., Röttger, A., & Steffel, K. (2004). Hibiscus: Post-production management for improved market access organisation: Food and Agriculture Organization of the United Nations (FAO), AGST.

Popper, R. (2014). Use of Just-About-Right scales in consumer research. In P. Varela & G. Ares (Eds.), *Novel Techniques in Sensory Characterization and Consumer Profiling* (pp. 137-155). Boca Raton: CRC Press

Ramírez-Rodrigues, M. M., Balaban, M. O., Marshall, M. R., & Rouseff, R. L. (2011). Hot and cold water infusion aroma profilesof Hibiscus sabdariffa: fresh compared with dried. Journal of Food Science, 76(2), C212-C217. doi: 10.1111/j.1750-3841.2010.01989.x

Ross, I. A. (2003). Medicinal plants of the world (Vol. 1). Totowa, NJ: Humana Press.

Sáyago-Ayerdi, S. G., Arranz, S., Serrano, J., & Goñi, I. (2007). Dietary fiber content and associated antioxidant compounds in roselle flower (Hibiscus sabdariffa L.) beverage. Journal of Agricultural and Food Chemistry, 55(19), 7886-7890. doi: 10.1021/jf070485b

Williams, A., Carr, B.T., & Popper, R. (2011). Exploring analysis options for check-all-that-apply (CATA) questions. Paper presented at the 9th Rose-Marie Sensory Science symposium, Toronto, Canada.

Annex 1. Baobab consumer questionnaire

AFTER PT OUT14 BAOBAB

Q49

Q37 Muito obrigada por participar nesta sessão de avaliação de bebidas, que terá uma duração aproximada de 10 minutos. Ser-lhe-à pedido que prove 4 bebidas, uma de cada vez, por uma ordem predeterminada, e que responda a algumas questões. Leia cuidadosamente as instruções à medida que forem aparecendo no ecrã do seu computador. Por favor não troque impressões com os outros provadores. Não existem respostas certas ou erradas, o importante é podermos obter a sua opinião pessoal. Note que, uma vez respondidas as questões, o software não lhe permitirá retornar aos ecrãs precedentes. Não hesite em solicitar ajuda se tiver alguma dúvida ou se precisar de qualquer tipo de assistência. Dê agora início à sua participação clicando em >>. Obrigada!

Q5 POR FAVOR INDIQUE Sexo:

- Feminino (1)
- Maculino (2)

Q7 Ano de nascimento:

- ❍ 1935 (1)
- ❍ 1936 (2)
- ❍ 1937 (3)
- ❍ 1938 (4)
- ❍ 1939 (5)
- ❍ 1940 (6)
- ❍ 1941 (7)
- ❍ 1942 (8)
- ❍ 1943 (9)
- ❍ 1944 (10)
- ❍ 1945 (11)
- ❍ 1946 (12)
- ❍ 1947 (13)
- ❍ 1948 (14)
- ❍ 1949 (15)
- ❍ 1950 (16)
- ❍ 1951 (17)
- ❍ 1952 (18)
- ❍ 1953 (19)
- ❍ 1954 (20)
- ❍ 1955 (21)
- ❍ 1956 (22)
- ❍ 1957 (23)
- ❍ 1958 (24)
- ❍ 1959 (25)
- ❍ 1960 (26)
- ❍ 1961 (27)
- ❍ 1962 (28)
- ❍ 1963 (29)
- ❍ 1964 (30)
- ❍ 1965 (31)
- ❍ 1966 (32)
- ❍ 1967 (33)
- ❍ 1968 (34)
- ❍ 1969 (35)
- ❍ 1970 (36)
- ❍ 1971 (37)
- ❍ 1972 (38)
- ❍ 1973 (39)
- ❍ 1974 (40)
- ❍ 1975 (41)
- ❍ 1976 (42)
- ❍ 1977 (43)

- ❍ 1978 (44)
- ❍ 1979 (45)
- ❍ 1980 (46)
- ❍ 1981 (47)
- ❍ 1982 (48)
- ❍ 1983 (49)
- ❍ 1984 (50)
- ❍ 1985 (51)
- ❍ 1986 (52)
- ❍ 1987 (53)
- ❍ 1988 (54)
- ❍ 1989 (55)
- ❍ 1990 (56)
- ❍ 1991 (57)
- ❍ 1992 (58)
- ❍ 1993 (59)
- ❍ 1994 (60)
- ❍ 1995 (61)
- ❍ 1996 (62)
- ❍ 1997 (63)
- ❍ 1998 (64)
- ❍ 1999 (65)
- ❍ 2000 (66)

Q15 Nacionalidade:

- ❍ Portuguesa (1)
- ❍ Outra, por favor especifique: (2) _____

Q12 País de residência

- ❍ Portugal (1)
- ❍ Outra, por favor especifique: (2) _____

Q39 Nível de estudos

- ❍ 9º ano ou menos (1)
- ❍ 10º, 11º ou 12º ano (2)
- ❍ Bacharelato ou licenciatura (3)
- ❍ Mestrado ou doutoramento (4)

Q17 Costuma consumir bebidas ou sumos à base de fruta?

- ❍ Sim, diariamente (1)
- ❍ Sim, uma ou mais vezes por semana (2)
- ❍ Sim, uma ou mais vezes por mês (3)
- ❍ Raramente (4)
- ❍ Nunca (5)

Q18 Porque consome bebidas ou sumos à base de fruta? (Assinale todas as razões que se apliquem)

- ❑ Sabor (1)
- ❑ Saúde (2)
- ❑ Energia (3)
- ❑ Matar a sede/refrescar (4)
- ❑ Nutrição (5)
- ❑ Preço acessível (6)
- ❑ Hábito (7)

Q23 Por favor prove agora a bebida 243

Q25 GLOBALMENTE, QUANTO GOSTOU da bebida 243?

- ❍ Gostei extremamente (1)
- ❍ Gostei muito (2)
- ❍ Gostei moderadamente (3)
- ❍ Gostei ligeiramente (4)
- ❍ Não gostei nem desgostei (5)
- ❍ Desgostei ligeiramente (6)
- ❍ Desgostei moderadamente (7)
- ❍ Desgostei muito (8)
- ❍ Desgostei extremamente (9)

Q26 Para si, a COR da bebida 243 é:

- ❍ Demasiado clara (1)
- ❍ Como gosto (2)
- ❍ Demasiado escura (3)

Q27 Para si, a DOÇURA da bebida 243 é:

- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q54 Para si, a ACIDEZ da bebida 243 é:
- Insuficiente (1)
- Como gosto (2)
- Excessiva (3)

Q60 Para si, o SABOR A FRUTA da bebida 243 é:
- Insuficiente (1)
- Como gosto (2)
- Excessivo (3)

Q30 CONSUMIRIA a bebida 243, se ela estivesse disponivel no mercado?
- 10- Sim (1)
- 9- É quase certo (2)
- 8- Muito provavelmente (3)
- 7- Provavelmente (4)
- 6- Boa possibilidade (5)
- 5- Possibilidade média (6)
- 4- Possibilidade razoável (7)
- 3- Alguma possibilidade (8)
- 2- Possibilidade ligeira (9)
- 1- Possibilidade muito ligeira (10)
- 0- Não (11)

Q69 Por favor prove agora a bebida 171.

Q52 GLOBALMENTE, QUANTO GOSTOU da bebida 171?
- Gostei extremamente (1)
- Gostei muito (2)
- Gostei moderadamente (3)
- Gostei ligeiramente (4)
- Não gostei nem desgostei (5)
- Desgostei ligeiramente (6)
- Desgostei moderadamente (7)
- Desgostei muito (8)
- Desgostei extremamente (9)

Q57 Para si, a COR da bebida 171 é:
- Demasiado clara (1)
- Como gosto (2)
- Demasiado escura (3)

Q56 Para si, a DOÇURA da bebida 171 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q55 Para si, a ACIDEZ da bebida 171 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q61 Para si, o SABOR A FRUTA da bebida 171 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessivo (3)

Q53 CONSUMIRIA a bebida 171, se ela estivesse disponivel no mercado?
- ❍ 10- Sim (1)
- ❍ 9- É quase certo (2)
- ❍ 8- Muito provavelmente (3)
- ❍ 7- Provavelmente (4)
- ❍ 6- Boa possibilidade (5)
- ❍ 5- Possibilidade média (6)
- ❍ 4- Possibilidade razoável (7)
- ❍ 3- Alguma possibilidade (8)
- ❍ 2- Possibilidade ligeira (9)
- ❍ 1- Possibilidade muito ligeira (10)
- ❍ 0- Não (11)

Q76 Por favor prove agora a bebida 514.

Q63 GLOBALMENTE, QUANTO GOSTOU da bebida 514?
- ❍ Gostei extremamente (1)
- ❍ Gostei muito (2)
- ❍ Gostei moderadamente (3)
- ❍ Gostei ligeiramente (4)
- ❍ Não gostei nem desgostei (5)
- ❍ Desgostei ligeiramente (6)
- ❍ Desgostei moderadamente (7)
- ❍ Desgostei muito (8)
- ❍ Desgostei extremamente (9)

Q62 Para si, a COR da bebida 514 é:
- ❍ Demasiado clara (1)
- ❍ Como gosto (2)
- ❍ Demasiado escura (3)

Q61 Para si, a DOÇURA da bebida 514 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q60 Para si, a ACIDEZ da bebida 514 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q62 Para si, o SABOR A FRUTA da bebida 514 é:
- ❍ Insuficiente (1)
- ❍ Como gosto (2)
- ❍ Excessiva (3)

Q58 CONSUMIRIA a bebida 514, se ela estivesse disponivel no mercado?
- ❍ 10- Sim (1)
- ❍ 9- É quase certo (2)
- ❍ 8- Muito provavelmente (3)
- ❍ 7- Provavelmente (4)
- ❍ 6- Boa possibilidade (5)
- ❍ 5- Possibilidade média (6)
- ❍ 4- Possibilidade razoável (7)
- ❍ 3- Alguma possibilidade (8)
- ❍ 2- Possibilidade ligeira (9)
- ❍ 1- Possibilidade muito ligeira (10)
- ❍ 0- Não (11)

Q161 Por favor prove agora a bebida 663.

Q162 GLOBALMENTE, QUANTO GOSTOU da bebida 663?

- Gostei extremamente (1)
- Gostei muito (2)
- Gostei moderadamente (3)
- Gostei ligeiramente (4)
- Não gostei nem desgostei (5)
- Desgostei ligeiramente (6)
- Desgostei moderadamente (7)
- Desgostei muito (8)
- Desgostei extremamente (9)

Q163 Para si, a COR da bebida 663 é:

- Demasiado clara (1)
- Como gosto (2)
- Demasiado escura (3)

- Q164 Para si, a DOÇURA da bebida 663 é:
- Insuficiente (1)
- Como gosto (2)
- Excessiva (3)

Q165 Para si, a ACIDEZ da bebida 663 é:

- Insuficiente (1)
- Como gosto (2)
- Excessiva (3)

Q166 Para si, o SABOR A FRUTA da bebida 663 é:

- Insuficiente (1)
- Como gosto (2)
- Excessiva (3)

Q167 CONSUMIRIA a bebida 663, se ela estivesse disponivel no mercado?

- 10- Sim (1)
- 9- É quase certo (2)
- 8- Muito provavelmente (3)
- 7- Provavelmente (4)
- 6- Boa possibilidade (5)
- 5- Possibilidade média (6)
- 4- Possibilidade razoável (7)
- 3- Alguma possibilidade (8)
- 2- Possibilidade ligeira (9)
- 1- Possibilidade muito ligeira (10)
- 0- Não (11)

Q53 Muito obrigada pela sua participação